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THE PRINCIPAL, I.C.T.A.

Managing Editor:
THE REGISTRAR, I.C.T.A.

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EDITORIAL

OIL PALM RESEARCH IN THE BELGIAN CONGO

ON page 29 of this issue appears an article by W. G. Kovachich which the author describes as "an initial contribution to investigations of the diseases of the Oil Palm". This article is the first of three which have been contributed to " Tropical Agriculture " through Professor C. W. Wardlaw, Professor of Cryptogamic Botany in the University of Manchester. The other two articles will be published in our next issue. One, "A Reconnaissance of the American Oil Palm ", by S. de Blank, is the result of a very extensive tour made by the author in South America. The special interest of the American Oil Palm is that it may be used in breeding experiments designed to improve the West African Oil Palm. The third article is another by Mr. Kovachich, entitled " Little Leaf Disease of the Oil Palm in the Belgian Congo ".

Professor Wardlaw has already published two introductory articles on diseases of the Oil Palm, describing the occurrence and symptoms of Vascular Wilt Disease, (1) and Armillaria root and trunk rot.(2) A considerable body of research work on the Oil Palm is being undertaken in the Belgian Congo and West Africa ; Professor Wardlaw is actively associated with these developments, which are under the immediate direction of Mr. de Blank.

(1) C. W. Wardlaw, *Tropical Agriculture* Vol. XXVII, page 42, 1950.
(2) Ibid, page 95.

A Cacao Collecting Expedition to the Amazon Valley in Colombia

Travellers in the densely forested area of South America east of the Andes, comprising the boundary areas of Venezuela, Brazil, Colombia and Peru, and including parts of the drainage basins of the Orinoco and Amazon, have found cacao plants growing in the wild state. The region has been considered the possible centre of origin of the species, and may contain the largest variety of distinct types. The study of these will assist in the classification of the cultivated varieties.

The British West Indies Cacao Research Scheme considered the possibility of sending a team of scientists to the region to study wild cacao and to collect material for genetical studies and the improvement of cultivated types. Mr. F. W. Cope, Senior Geneticist of the Scheme, visited Bogotá late in 1951 and learnt that the Colombian Government was not only willing to permit the scientists to explore Colombian territory, but would also assist by sending some of its own scientists with the party. The Colombian authorities will also allow the use of the Estación Agricola Experimental at Palmira in exchange for some of the material to be collected. The British section of the expedition will consist of a plant breeder, a plant pathologist and an entomologist.

The areas to be explored are densely forested, sparsely inhabited, and only small areas have been surveyed. The usual means of travel will be by canoe over the tributaries of the Amazon, as these provide the easiest means of communication. The party will limit itself to examination of the trees which are accessible from the river banks.

The expedition is expected to take about one year, and depending on the size and nature of the wild cacao population encountered may collect as many different genetic types as could otherwise be obtained only by several years' study among cultivated trees. Diseases of wild cacao and their distribution will be studied and resistant material collected in the hope that it will aid the production of better disease resistant types. The purpose of the expedition is not to collect outstanding material for immediate cultivation, but to make available a store of germoplasm for use in future breeding work. A search will also be made for parasites of mealy bugs and other insect pests of cacao.

REVIEW ARTICLES AND BOOK REVIEWS

GENERAL AGRICULTURE : AGRICULTURAL BOTANY

MANAGEMENT AND CONSERVATION OF VEGETATION IN AFRICA

Commonwealth Bureau of Pastures and Field Crops, Bull. 41 (1951). *pp.* 96. 38 *photographs.* 6 *maps. Price :* 10/6*d.*

THIS is a slim volume whose contents are equally slender. The expensive but unattractive format to which the Bureaux now seem to be wedded lends little to this somewhat meagre account of a vitally important subject. Individually the papers on the various territories are not without interest, with the exception of that on the Sudan which is presented in a form conveying little to anyone who is not familiar with that country.

One could wish for documentation of many of the statements, for example (p. 18) that under the impenetrable thickets of thorn scrub the soil " begins to erode ". Is thorn scrub not nature's attempt to limit man's destructive range ?

There are several photographs, many of which are good, but not one aerial photograph, nor can any reference to aerial survey be found ; a notable omission in this year of grace. It would have been better to omit the photographs of the once notorious Ground Nut Scheme.

No one should disagree with Edwards' conclusion (p. 39) that " no amount of effort expended in the present methods of soil conservation can be expected to induce recovery unless readjustment of the forms of human occupation to the natural conditions of the area concerned can first be attained."

His plea for an ecological survey, combining, it is hoped, a land utilisation survey with one of vegetational types, should by now not be necessary. If a fraction of the money spent on the Ground Nut Scheme had been devoted to such surveys the rest of the money would have been saved.

G. ap G.

FLORA OF THE BRITISH ISLES

By

A. R. Clapham, T. G. Tutin and E. F. Warburg. *Cambridge University Press, London, Pp.* 1592, *Text-figures* 320. *Price* 50/-

The production of a new Flora of the British Isles is an event which should not pass unnoticed even by a journal of tropical agriculture. In the past, generations of students who have later migrated to the tropics have cut their teeth on Hooker's Student Flora, future generations will no doubt be brought up on Clapham, Tutin and Warburg.

To one who used to know the easier parts of the British Flora fairly well, but who has for the last twenty years only seen it for some three months every three years or so, this book is of absorbing interest. The first point that strikes one is that somehow the Flora seems to have grown bigger and become more complex since one's student days. This is partly due to the erroneous idea of some tropical botanists that, compared with their own problems, those of the British botanist are few and small, and that anybody can learn the British flora if they devote an hour or two of spare time a week to it ; it is partly also due to the over-simplification of earlier works ; but most of it is a tribute to the great increase of knowledge of the British flora made in the present century as well as to the industry and patience of the authors of this work. Great changes have, for instance, been made in the Orchidaceae, Cyperaceae and the genus *Euphrasia*, to mention but a few. All may not welcome a specialist tendency to split families and genera, but if precision is achieved thereby in what is, after all, to be a standard work for many years, there can be nothing but profit in this treatment.

The authors have not hesitated to mention introduced aliens and garden plants. This is of interest to all and will be of great help to beginners, who are often baffled by being unable to find common plants in their flora because they are not native.

Great strides made in recent years with the county floras and ecological work generally have enabled the authors to give much better and more precise field notes than has been done hitherto. One is glad to see that in some instances they appear to have been purposely vague in not giving away the exact localities of rare plants ; 'Eastern Counties—very rare' is quite precise enough for a plant having, perhaps, only one or two stations in the Brecklands.

Finally, the keys and descriptions *look* workable ; testing them out will have to remain a pleasure in store until next leave.

The authors are to be congratulated on an excellent piece of work which should become a school and university best-seller.—R.E.D.B.

THE ORIGIN, VARIATION, IMMUNITY AND BREEDING OF CULTIVATED PLANTS

Selected Writings of N. I. Vavilov translated from the Russian by K. STARR CHESTER, PH.D. *Published as Chronica Botanica, Vol. 13. No. 1/6. Waltham, Mass., The Chronica Botanica Co. : London, Wm. Dawson & Sons, Ltd. Price* $7.50 (U.S.)

NIKOLAI IVANOVICH VAVILOV was born in 1887 and died probably in the early months of 1942. From 1921 to 1934 he directed the work of more than 400 research institutes and experiment stations and was directly responsible for the celebrated Russian work on the collection of economic plants. The preface of this work, and here the editor should have been much more precise, implies that these five papers or essays are Vavilov's contribution to ' The scientific bases of Plant Breeding ' a compendious publication of some 2,500 pages of which Vavilov was the editor and principal author in 1935.

The first of these, entitled ' Plant Breeding as a Science ' (11 pages) is a useful general statement from an authoritative source. The second essay, ' Phytogeographic Basis of Plant Breeding ' (40 pages) is a statement on the centres of origin of cultivated plants. Eight independent centres, Chinese, Indian and Indo-Malayan, Central Asiatic, Near East, Mediterranean, Abyssinian, Central American and South American, are discussed and exhaustive lists given of the cultivated plants which have originated in each. The conclusion is reached that the study of the world's plant resources has barely begun and that enormous untouched reserves of breeding material have been discovered.

The third essay is effectively a reprint of Vavilov's classic ' The Law of Homologous Series in the Inheritance of Variability ', which was published in English in the Journal of Genetics in 1922, and which can therefore hardly be said to be presented to those who cannot read Russian for the first time.

The fourth essay ' The Study of Immunity of Plants from Infectious Diseases ' is a somewhat ill-digested but compendious review of the enormous literature on the subject up to 1934.

The last essay on ' The Scientific Bases of Wheat Breeding ' (180 pages) comprises more than half of the present volume and can have little general interest except to wheat-breeders.

The main use of the present work, while paying a fitting tribute to the immense industry and knowledge of Vavilov, will be the making available of Russian work either previously unavailable or else available only as scattered abstracts. Production is generally good although it is a pity that so large a publication should be printed with paper backs. The editor's habit of mixing the illustrations to the fifth and last essay with the preface, title-page and table of contents is to be deplored.

The indices of authors and plant names add considerably to the value of this book, making it, effectively, a useful reference book.—R.E.D.B.

IMPORTANT GRASSLAND PLANTS OF KENYA

By D. C. Edwards and A. V. Bogdan. *Sir Isaac Pitman & Sons, Ltd., London. Pp. xii,+124, Ill. Price* 20/-

The primary aim of this book is to enable farmers and field officers of the Agricultural Department to recognize the more important constituents of the herbage of the grasslands of Kenya—an ambitious object for a book of only 124 pages. Part I, of thirteen pages is devoted to a brief description, illustrated by eight excellent photographs of the natural grasslands, which are divided into Highland grassland, Scattered tree grassland (two types), Open high-grass glades of the coastal bush, and the semi-desert grassland. Most of Part II, some 70 pages, consists of a description of a selection of the more important of the 450 or so grasses of the territory. Fairly full botanical descriptions are given in simple language, and the species described are illustrated by line drawings. The main risk here would appear to be that so often experienced by a semi-popular work, that it will be too difficult for the non-botanist and too sketchy for the trained worker. The remaining sections of this part, on the legumes, sedges and other plants, only give the briefest introduction to the enormous and diverse flora of the country.

In these days of high printing costs 20/- is probably not an excessive price to pay for a book so well printed and illustrated.—R.E.D.B.

SOIL SCIENCE

KRILIUM

KRILIUM is a synthetic resin which acts like the natural polysaccharide and polyuronide gums, produced by decomposing plant residues and by certain soil micro-organisms, to bind together particles of clay to form stable aggregates such as comprise soil-crumb. It is manufactured by the Monsanto Chemical Company of 1700, South Second Street, St. Louis, 4, Missouri, U.S.A., who announced its successful development in December, 1951.

Krilium is a pale-yellow, finely-crystalline, hygroscopic powder. Chemically, it is probably the sodium salt of hydrolysed polyacrylonitrile, which is derived either from ethylene or acetylene, and used in the manufacture of certain textile-fibres, plastics and synthetic rubbers. It is readily soluble in water, ionising to produce large polyvalent anions. It is a colloidal electrolyte. Its aqueous solutions are highly alkaline (pH 9.6 in 0.1 percent. solution ; pH 9.0 in 0.5 percent. solution, and pH 8.2 in 5 percent. solution), presumably because the substance is a salt of a strong base and a weak acid. Krilium is said to be precipitated from aqueous solution by acids and by calcium ions and aluminium ions when added in high concentration. Its solutions are markedly viscous, even at low concentrations.

The efficacy of Krilium in binding clay particles together depends on its strong adsorption by the particles and the linking effect of the carbon " bridges " between the reactive groups of the Krilium polymer. The degree of adsorption is stated to be approximately equal to " the *anion* exchange capacity of the clay." This last statement would imply that clay colloids normally behave as polyvalent *cations*, which is contrary to the usually-accepted view that they (at least the alumino-silicate clays) behave like colloidal *anions* (with negative electric charge), and thus exhibit base-exchange capacity. Their iso-electric points are generally believed to be low down on the pH scale (e.g. pH 3.0). Maximum aggregating effect at low concentrations of Krilium is said to be obtained in the presence of small concentrations of sodium, calcium, magnesium and other cations, occurring naturally in most soils. Although water-soluble, Krilium is completely resistant to leaching " because of its firm adsorption by the clay particles ".

One pound weight (1 lb.) of Krilium is stated to have the same soil-improving (aggregate-forming) capacity as the natural gums produced by 100 to 1,000 lb. of plant residues or organic manures, and to retain this capacity against decomposition by soil micro-organisms, in some cases at least 10 times as long as natural soil organic matter. The treatment of soil in the field by Krilium is best carried out when the soil is dry and can be pulverised by discing, harrowing or raking to a depth of about 3 inches. The appropriate amount of Krilium, mixed if necessary with a filler such as ground limestone,

is then broadcast over the soil and watered in or left until the rain washes it in. Preferably it should first be lightly worked into the soil. Krilium may also be added to the row during the drilling of seeds. For stabilising a granular soil surface and thus ensuring high infiltrability to rain (necessary, for example, in anti-erosion work), Krilium should be broadcast evenly on the soil surface as a " holding treatment " until a vegetative cover can be formed. Seeds germinate readily in a stabilised granular surface of this nature.

On treatment with Krilium, the soil becomes porous and friable within 24 hours ; the aggregates that are formed range in size from pin-head to pea. When tilled, the soil offers much less resistance to implements and is remarkably easy to work. Moisture is essential for the full development of the aggregate or crumb structure, in amount between 15 and 20 percent. by weight of soil. The crumb is extremely stable to water and resists the beating action of rain. Both capillary and non-capillary pore-space are increased ; water-holding capacity and permeability are consquently increased and loss of water by evaporation is greatly reduced. Aeration and root penetration are enhanced, and surface crusting is prevented. The quantities advised for use in the field range from 0.02 percent. to 0.10 percent. on weight of soil. Amounts greater than 0.2 percent. may be detrimental. Assuming one acre three inches of soil weighs one million pounds, then 0.02 percent. by weight *equals* 200 lb. per acre, and 0.10 percent. equals 1,000 lb. per acre, which is the range of magnitude of the dressings advised. Assuming the optimum is 0.05 percent., then the best dressing is 500 lb. per acre. The length of time of effectiveness may be 30 times as great as that of organic composts. Soil deterioration in greenhouse beds or field plots was not observed within 3 years of the time of application of Krilium, although the structure can be destroyed by compaction or overworking.

Storage in dry places and in tight containers is advised, since Krilium is somewhat hygroscopic. Krilium is chemically inert and may be mixed with fertilizers (except ammonium nitrate), ground limestone and other soil amendments.

Krilium is being tested by field experiments at many agricultural research stations in different parts of the world, including some of the foremost stations in U.S.A. and also Rothamsted in England. It has not yet been put on the market for sale, but it will probably cost at first about 2 dollars (American) per pound. It is believed that the price will drop rapidly when the material comes into large-scale production. Plans are afoot to erect in 1953 a 50 million-dollar factory in Texas for the manufacture of Krilium from certain products of the mineral oil industry, possibly ethylene.

The Monsanto Company has agreed to supply to the Soils Department of the College within the next few weeks a sample of Krilium for experimental testing.—F. H.

PLANT PESTS AND DISEASES

A REVIEW OF THE POSITION WITH REGARD TO SUGAR-CANE LEAF SCALD IN BRITISH GUIANA

BY

W. T. DALE

Identity of the Disease

A disease of the sugar-cane variety B.34104 at Plantation Uitvlugt, British Guiana, was found to agree in its external and internal symptoms with leaf scald, a bacterial disease caused by *Xanthomonas albilineans* (Ashby) Dowson (Dale, 1950). A subsequent survey has revealed the disease in a number of cane varieties on almost all plantations in the Colony, and on one over the border in Dutch Guiana. It occurs in canes of all ages, from plants to old ratoons, and presents a serious threat to the sugar industry of the area. Bacteria isolated from affected material by Hutchinson (1951) and Wiehe (1951) reproduced the symptoms when inoculated to healthy setts, and were re-isolated. Cultures sent to Dr. W. J. Dowson of the Botany School, Cambridge, are considered by him (in litt.) very similar to a strain of X. *albilineans* from Queensland.

Leaf scald occurs in Australia, Fiji, Formosa, Hawaii, Java, Madagascar, Mauritius, the Philippines, Réunion, Brazil, and possibly Japan and New Guinea (C.M.I., 1947). In most of these countries it has been known for a number of years. The record from Brazil (Arruda and Amaral, 1945) is the only previous one from the Americas. From its widespread distribution, the disease seems to have been in British Guiana for some time. It may have arrived with the tolerant P.O.J. 2878 from Java about 1928 and remained undetected prior to the widespread use of varieties now known to be very susceptible.

Symptoms

The symptoms of leaf scald have been fully described, notably by Wilbrink (1920), North (1926, 1929), Martin, Carpenter and Weller (1932) and Arruda and Amaral (1945) ; they need only be briefly repeated here. The accompanying Plate, from a water-colour sketch by G. C. Stevenson, illustrates the essential external and internal features. Fine clear-cut white streaks appear on the young leaves. These run parallel to the veins, extending over a part or the whole of the blade and sometimes into the sheath. A fine red line often occurs centrally within the white streak. At times, green pigmentation disappears almost entirely from the lamina. As infection progresses, the leaves wilt and finally die, the presence of dry tillers in affected stools becoming an obvious symptom. Infected mature canes produce an abnormal development of side shoots, which usually show marked leaf symptoms.

When infected canes are split longitudinally, a yellowish red discolouration of the tissues around the growing point is evident ; also a purplish red discolouration of the vasculars below. The latter is most obvious in mature canes, and is particularly marked at the nodes, though internodal vasculars may also be affected. The colour appears to be due to development of a pinkish gum, doubtless a wound reaction.

Varietal Susceptibility

Overseas work has shown that cane varieties differ greatly in their susceptibility to leaf scald ; some, though not completely immune, are at least sufficiently resistant to be commercially successful. Similar variation is indicated amongst varieties available in British Guiana, by both field observations and artificial infection experiments. B.34104 and D.14/34, which accounted for 70 per cent. and 15 per cent. respectively of plantings in 1950, are very susceptible and must be replaced as soon as practicable ; but the three promising varieties B.37161, B.4098 and B.41227 are more resistant, and there is reasonable hope that their use, coupled with other control measures, will maintain sugar production at its present level (Wiehe, 1951).

Crop Sanitation Measures

Until immune or highly resistant varieties become available for large scale planting, it is imperative that strict crop sanitation should be practised by all estates to prevent, as far as possible, the spread of leaf scald in the promising varieties named above, and to minimise losses in crops of more susceptible ones until it is practicable to replace them entirely. The following measures are advocated (Wiehe, 1951).

(*a*) The selection of fields showing slight or, if possible, no infection as a source of planting material is essential. These should be inspected at monthly intervals and all diseased stools rogued. In spite of these precautions, some infected but symptomless stools will remain, so it is desirable to disinfect the knives frequently while preparing cuttings, thus reducing contamination of healthy material.

(*b*) After the reaping of a field is completed all knives should be sterilised to prevent transmission to healthy fields. This is particularly important when one of the more promising varieties mentioned above is to be harvested immediately after a field of B.34104.

(*c*) All young plant canes should be examined for infected stools and these removed.

Experimental Programme

A programme of experimental work designed to provide much needed information on leaf scald has been started (Wiehe, 1951). The main points of this are set out below.

(*a*) Studies on the identity of the causal organism are being undertaken by Dr. Dowson at Cambridge. *Xanthomonas albilineans* apparently exists

LEAF SCALD
DISEASE

in different strains. Bacteria resembling it are known to occur on certain grasses in Mauritius and Colombia. A search for possible wild hosts in British Guiana assumes importance in relation to the control measures recommended.

(*b*) Apart from transmission by infected setts or knives, little is known about the manner in which the disease is spread and gains entry into the plant. It is generally believed that the organism cannot survive in the soil. Precise information on this point is fundamental with regard to control measures. Of particular importance is the possibility of survival of the bacterium on dam-beds, which do not become inundated during the flood-fallowing practised on most of the plantations. The investigation of possible transmission by insects and rats is being initiated.

(*c*) The effect of leaf scald on yield and juice quality will be studied ; also the effect of environmental factors, particularly soil moisture, on incidence of the disease.

(*d*) The ultimate control of this pathogen must depend, as in other countries, on the replacement of susceptible varieties by resistant ones. The testing of varieties for resistance, started by Hutchinson (1951) and continued by the Department of Agriculture, has already yielded very useful information. Further experimental work is necessary, however, to place the testing technique on a sound basis, and so provide planter and plant breeder with accurate data on the leaf scald reaction of new seedlings.

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MANUAL OF BACTERIAL PLANT PATHOGENS, 2ND EDITION (ANNALES CRYPTOGAMICI ET PHYTOPATHOLOGICI, VOL. 10)

By Charlotte Elliott. *Waltham, Mass.—Chronica Botanica Co. : London, W.C. 2—Wm. Dawson & Sons, Ltd.* 1951, pp. 186. *Price* $6.00 (*U.S.*).

The original edition of this work was published in 1930, since when a great deal of information on bacterial plant pathogens has accumulated. Thus, the publication of a second edition, bringing together information available to date, is most welcome. Part I deals with recognized bacterial plant pathogens, Part II with species reported in the literature from plants, but not regarded as valid pathogens ; in both, genera and species are arranged alphabetically. The nomenclature largely follows that of the 1948 edition of Bergey's Manual of Determinative Bacteriology.

The following information on each organism is presented in a uniform manner throughout : the accepted name and synonyms, with citations ; morphological and physiological data ; symptoms and host range ; geographical distribution ; control measures (if any) ; a full list of references. The book has an index of plant hosts and another of the bacteria, which are listed alphabetically by specific epithets—a most convenient arrangement. This is indeed a most useful manual, to which every plant pathologist should have access.—W.T.D.

ELEMENTS OF PLANT PROTECTION

By L. L. Pyenson, ph.d. *John Wiley and Sons, Inc., New York,* 1951. *Pp.* x+538. *Price :* $4.96 (U.S.)

The Publishers state that this admittedly elementary book " brings together information on all plant pests—insects, disease-producing organisms, rodents, birds and weeds ". So it does—for the United States—but since no examples are given from any other country it will be of little value to students elsewhere.

It is perhaps symptomatic of the present trend of plant protection in America that the discussion of control methods, other than chemical, of invertebrates is dismissed in some seven pages, less than half a page being devoted to parasites. Similarly, non-chemical methods of control of plant diseases occupy four pages only.

It is, however, well up-to-date on the newer organic insecticides and weed-killers.

The book is printed, like a page of typescript, without alignment of the right-hand ends of the lines. Hyphens are liberally used to subdivide long words at the end of a line, with little regard for the rules of hyphenating.

T.W.K.

ANIMAL HUSBANDRY : PLANT AND ANIMAL NUTRITION

FARMER AND STOCK-BREEDER YEAR BOOK 1952

"Farmer and Stock-Breeder Year Book 1952". *The 76th edition, published on December 3rd, 1951 by Farmer and Stock-Breeder Publications Limited, Dorset House, Stamford Street, London, S.E.1. Size D8vo.* $8\frac{3}{4}$ x $5\frac{1}{2}$" *412 pages. Over 170 illustrations. Quarter-bound paper boards. Price* 10s. 6d. (*Postage* 6d.)

New machinery is again covered in detail in a 15-page article, other articles by acknowledged authorities include :

Controlled Grazing (by James Mackintosh)
Choice of a Root Crop (Dr. D. H. Robinson)
Dried Grass (Dr. R. E. Slade)
Quality in Bacon Pigs (Paul Vestbirk)
Prospects for Sheep (Prof. R. G. White)
Pitfalls in Silage Making (Prof. H. I. Moore)
Horticulture's Problems (E. H. Gardener)
Turkeys (Rupert Chalmers Watson)
Laying Pullet Management (Dr. D. J. G. Black).

G.H.W.

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THE CLASSIFICATION OF WEST AFRICAN LIVESTOCK

By I. L. Mason. *Technical Communication No. 7 of the Commonwealth Bureau of Animal Breeding and Genetics. Commonwealth Agricultural Bureaux, Farnham Royal, Bucks.* 1951. *Pp.* 39. *Price* 10/6.

There has always been some difficulty in the scientific classification of the different classes of livestock found in the various areas of West Africa and those areas to the immediate north. In addition any attempt at classification has been made more difficult by the many varied and local names given to the so-called "Breeds" or types, by their owners. This small booklet contributes some cogent material which cannot but aid any future investigations. There is a wealth of fact and knowledge which has been collected from many sources and the photographs of the various types of Livestock of West Africa are excellent.—G.H.W.

THE DIAGNOSIS OF MINERAL DEFICIENCIES IN PLANTS

By T. Wallace. (*2nd Edition*) *H.M.S.O., London*, 1951. *Pp. viii*+107, *Ill.* 312 *Colour plates. Price* 35/-

The appearance of Prof. Wallace's well-known work under one cover will be welcomed by all interested in plant nutrition. The inclusion of 312 coloured plates of deficiency symptoms at the very modest price of 35/- is a creditable achievement due undoubtedly to the remarkable success of the first edition. In the present edition, introductory remarks on the function of essential elements and factors involved in their availability to the plant are brought up to date and a section is devoted to chemical tissue tests in the development of which one of Prof. Wallace's colleagues, Dr. Nicholas, has played a prominent part.

The crops dealt with are mostly crops of the temperate regions but quite a number of these crops are grown in the tropics particularly the vegetables and some of the cereals. Tropical workers will, therefore, find quite a proportion of interesting material in the book.

Most of the colour photographs are well executed and it should be emphasized in this connection that large close-up plates of a range of symptoms in leaves are more valuable than distant field views however spectacular the effects brought up in the latter.

It should also be emphasized that considerable skill and experience is required in making a certain diagnosis on visual symptoms alone and confirmatory methods such as by tissue tests, leaf injection techniques, &c. should be used wherever possible. Nevertheless a series of colour plates such as produced in the present work and in the American Potash Institute's publication "Hunger signs in crops" is a very real aid in diagnosis of symptoms of malnutrition.

There is some danger in a few instances of erroneous conclusions being drawn when no warning of other effects giving rise to similar symptoms is made. A case in point is the blossom end rot in tomatoes caused by calcium deficiency in Plate 254. Blossom end rot is, of course, of very frequent occurrence particularly in the tropics, but in most cases the condition is not caused by calcium deficiency but by large and sudden fluctuations in water content.

Prof. Wallace does indeed note the occurrence of complications caused by weather, soil, pests and diseases in using visual symptoms and prospective users of the book would do well to pay due attention to the manner in which the book should be used.—H.E.

BIBLIOGRAPHICAL

THE BIBLIOGRAPHICAL BASIS OF AGRICULTURAL RESEARCH WITH SPECIAL REFERENCE TO THE TROPICS

By

WILFRED J. PLUMBE

Librarian, Research Division, Ministry of Agriculture, Sudan Government.

For today's research worker in agriculture and its ancillary sciences a formidable accumulation of literature is available. During 1951 over 90,000 new papers, bulletins, leaflets, reports and books were published; and in the previous year the United States Department of Agriculture Library (largest agricultural library in the world, with a stock of over 750,000 volumes) added 42,215 items to its collection and received, in addition, over 14,000 serial publications.

Obviously, it has become increasingly difficult for the individual scientist to keep in touch with the literature of his subject. In tropical countries he rarely has access to a first-class agricultural library and even if he has he cannot read more than a small fraction of what is published. To keep abreast of current publications and remain familiar with older literature he must rely to an increasing extent upon bibliographies and abstracts. Knowledge of bibliographies has, in fact, become a pre-requisite of research.

The present article attempts to indicate what bibliographical aids exist. It should be regarded as a brief preliminary survey rather than an exhaustive analysis. Its intention is to try to help the worker who is new to tropical agriculture or who, perhaps, has been so long in the field that he is not familiar with recent literature, rather than anyone who possesses up-to-date and specialized knowledge of bibliographical resources.

Bibliographies of Agriculture in General

These fall into two groups: reference books and periodicals.

Reference Books

The fundamental guide to bibliographies of agriculture (and all other subjects) is T. Besterman's *World bibliography of bibliographies*, 2nd edition, 1950, in two volumes and an Index. It is the result of a great deal of painstaking research, it covers literature in all languages, and although not exhaustive it is a most impressive and helpful record, and is invaluable as a basis for literature searches in many subjects.

Certain works omitted by Besterman may be found in *International Bibliographie der Bibliographien*, 1950, compiled by H. Bohatta and F. Hodes: this is, however, less comprehensive than the British publication.

Surprisingly useful, too, in spite of brevity, is Lars Frykholm's 31-page *Översikt över lantbrukforskningens och dess hjälpvetenskapers viktigare bibliografiska hjälpmedel* ["Review of the more important bibliographical guides

to agricultural research and its ancillary sciences "] which was published at Uppsala in 1948. A supplement appeared in 1951.

More limited in scope is *A survey of current bibliographies on agriculture and allied subjects* issued by the International Institute of Agriculture, Rome, in 1937. A supplement to this, entitled *New agricultural bibliographical resources* was published in 1943.

A most useful bibliography of very wide scope is the *Bibliography of soil science, fertilizers and general agronomy*, published by the Commonwealth (formerly the Imperial) Bureau of Soil Science at Harpenden. The six volumes published cover the years 1931–1950. Entries are arranged according to the Universal Decimal Classification and also according to country, and there are author and subject indexes that are in every way excellent. By using the abstract journal *Soils and fertilizers* in conjunction with these six volumes, it is possible to trace—and quickly—practically all the literature that has appeared since 1930 concerning any crop, cultural method or other subject within the scope of the bibliography.

Little known in British territories is an important bibliographical service of the Institut National pour l'Etude Agronomique du Congo Belge (I.N.E.A.C.) at Brussels. The fortnightly *Fiches bibliographiques* issued by the Institut record a wide range of new literature concerning agricultural research in general and agricultural research in tropical and sub-tropical countries in particular. About 3,000 *fiches* a year are published. Although generally shorter and less factual than abstracts emanating from the Commonwealth Agricultural Bureaux they often appear earlier than the corresponding C.A.B. abstracts.

A "selective" bibliography of books published in English is the *Readers' guide to books on agriculture* (New series, No. 4), issued in 1950 by the County Libraries Section of the Library Association. It has been very carefully compiled, and although intended primarily for the user of public libraries in the United Kingdom it is also of value to the research worker overseas.

More restricted in scope than the *Readers' guide* is *Some books on agriculture, nutrition, forestry and related sciences*, 1939–1945, compiled by H. M. Bedington and published by the Imperial Agricultural Bureaux in 1946.

Another useful work is the *Selected list of publications on tropical agriculture*, which was prepared for the Inter-American Conference on Agriculture, Forestry and Animal Husbandry, in 1930.

Of particular interest to those in tropical Africa are *Bibliographie du Congo Belge et du Ruanda-Urundi* (1939-1947) : *agriculture*, by T. Heyse, published in 1948 ; and *Agricultural science in the Sudan : a bibliography with abstracts*, by R. L. Knight and B. M. Boyns, published in 1950. Both cover all branches of agriculture. The first contains 1,813 entries and the second 969.

Older bibliographies for other territories are *Philippine agriculture bibliography*, 1926, by E. R. Alvarado, and *Bibliography of Chinese literature on agriculture*, 1924, by Mao Yung.

In addition, the printed catalogues and accessions bulletins of tropical and sub-tropical agricultural libraries often form useful guides to literature.*

Three bibliographies which have a geographical limitation but are not restricted to one country are the *Bibliography of scientific publications of South Asia* (*India, Burma, Ceylon*), Nos. 1–4, covering the period January, 1949 to December, 1950, published by the UNESCO Science Co-operation Office for South Asia at Delhi; another UNESCO publication, the *List of scientific papers published in the Middle-East*, Nos. 1–6, 1948–1950; and the *Postwar scientific bibliography for Indonesia, 15th August, 1945–31st December*, 1949, which was issued in 1950 by the Indonesian Organization for Scientific Research, in Djakarta. These are not purely agricultural but they contain many entries which may be of interest to those engaged in agriculture.

It is well known that the activities of the United States Department of Agriculture cover a wide field. The publications of the Department are equally diversified and appear, in fact, in twenty-nine series : and even this excludes discontinued series, periodicals, motion pictures, photographs, slide-films, and visual aids. Miscellaneous publication No. 60, which is *List of available publications of the United States Department of Agriculture*, was published annually until 1942; since then it has appeared in 1945 and 1948 only. It is a useful check-list for those who need to keep abreast of American practice.

A useful "selective" guide to American books, distinct from purely official publications, is *Scientific, medical and technical books published in the United States of America*, a supplement to which, covering 1945–1948, appeared in 1950.

A basic general reference work that should never be overlooked is the *Catalogue of the books, manuscripts, maps and drawings in the British Museum of National History* in eight volumes (1903–1940), edited by B. D. Woodward.

Although not primarily of bibliographical interest, three encyclopaedias still in the process of publication contain a good deal of agricultural information of interest. *Encyclopédie du Congo Belge* is being published at Brussels in three volumes ; the first two volumes are available, and publication of the third is expected shortly. *Encyclopédie de l'Empire Francais* is to comprise eleven volumes. Two volumes dealing with French West Africa were published in 1949, the volume concerned with French Equatorial Africa appeared in 1950, and three volumes dealing respectively with Algeria and the Sahara, Tunusia, and Morocco, have also appeared. Still to be published is the volume covering Togoland and the French Cameroons. The *Encyclopédie d'Agriculture tropicale* is also French ; the three volumes published between 1941 and 1947 concern "Generalities", coconut palms, oil palms, and groundnuts ; five other volumes, covering soya beans, sesame, castor oil and other oil-yielding plants, are announced for future publication.

*Catalogues from such publishers and booksellers as the following are also useful in tracing publications :—Antiquariaat Junk (Lochem), A. Asher (Amsterdam), B. H. Blackwell (Oxford), Frances Edwards (London), R. Friedlander (Berlin), W. Heffer (Cambridge), Walter J. Johnson (New York), Paul Lechevalier (Paris), Lehnert & Landrock (Cairo), H. K. Lewis (London), McGraw-Hill (London), Bernard Quaritch (London), Frank R. Thorold (Johannesburg), Société d'Editions Geographiques, Maritimes et Coloniales (Paris), and Wheldon & Wesley (London).

An agricultural encyclopaedia announced for early publication by the Czechoslovak Academy of Agriculture is the *Great encyclopedia of agriculture.*

Bibliographical Periodicals

The *Bibliography of agriculture,* published monthly by the Library of the United States Department of Agriculture, is the most important and is indispensable. It is a classified record of current world publications in all languages, each month's issue containing between 7,000 and 8,000 entries with an author index. Cumulated author and subject indexes appear at the end of each year. There is probably no other bibliography on any subject equal to it in scope, accuracy and promptness of entry.

Also American is the monthly *Agricultural index* published by H. W. Wilson Co. This covers about 150 serials (all of them important) as compared with 15,000 (but not all of them important) covered by the U.S.D.A. *Bibliography of agriculture.*

The *Bibliography of tropical agriculture,* now defunct, is sometimes useful for reference purposes. It was published by the International Institute of Agriculture in Rome as an annual volume from 1932 to 1943, and the abstracts of which it consists are arranged in subject order, printed in English and French.

Reliance is often placed upon the abstract journals of the Commonwealth Agricultural Bureaux as bibliographies of current material. Although they frequently appear late these abstracts are universally esteemed. It may be useful to list the C.A.B. abstract journals as a group. They are :—*Soils and fertilizers ; Herbage abstracts ; Field crop abstracts ; Plant breeding abstracts ; Horticultural abstracts ; Dairy science abstracts ; Nutrition abstracts and reviews ; Animal breeding abstracts ; Helminthological abstracts ; Forestry abstracts ; The veterinary bulletin ; Review of applied mycology ; Review of applied entomology, series "A"* (Agricultural) and *series "B"* (Medical and veterinary).

Equally vital are *Biological abstracts* ; *Chemical abstracts* ; *British abstracts* ; and for U.S.D.A. publications up to 1946 the *Experiment station record. Agricultural and horticultural engineering abstracts* (formerly *Abstracts on agricultural and horticultural engineering*) is a relative newcomer ; it was started in 1950 by the National Institute of Agricultural Engineering at Silsoe.

Three other journals in English and four in French are also notable as bibliographical tools.

Colonial plant and animal products and *Colonial geology and mineral resources* are two journals which have replaced the *Bulletin of the Imperial Institute.* The *Bulletin I.A.I.* which the Institute for International Collaboration in Agriculture and Forestry at Prague began to publish in 1948, by providing summaries in English of papers that have appeared mainly in Russian and central European periodicals, has helped to lift the Iron Curtain a little so far as agriculture is concerned.

L'agronomie tropicale includes a " Documentation " section comprising book reviews, summaries of papers in other journals, and a part entitled " Bibliographie analytique " which consists of abstracts under such headings as Sols, Biologie des plantes cultivées, Défense des cultures, Chimie végétale, Forêts et bois. The summaries and abstracts are printed on one side of the paper only and may therefore be cut out and mounted on cards.

Annales agronomiques (*serie "A"* of *Annales de l'Institut National de la Recherche Agronomique*) is concerned primarily with France rather than with French territories overseas but it does frequently direct attention to items of tropical interest. It covers soil science, fertilizers, bioclimatology, and plant physiology, and has three main sections. " Documentation " contains material classified in such broad groups as Methodes et Techniques, Sols, Fertilisation des sols, Production végétale et Ameliorations des plantes cultivées. " Bibliographie " consists of a list of publications some of which are reviewed at length. " Sommaire des périodiques " gives the titles of papers in other journals, arranged according to language.

Bulletin agricole du Congo Belge has a substantial abstract section entitled " Bibliographie " which includes entries taken from the *Fiches bibliographiques* of I.N.E.A.C.

Also covering Belgian Congo is T. Heyse's *Index bibliographique colonial : Congo Belge et Ruanda-Urundi* (Inbicol). Publication of this began in 1937 and the last number appeared in April 1940. There are 10,000 notices in all.

The research worker, in all probability, will only occasionally need to refer to bibliographies of current publications in general. When he does, the best list for publications in the English language is the monthly *Cumulative book index* published by H. W. Wilson Co. of New York ; and for United Kingdom publications only the monthly *British national bibliography* compiled at the British Museum. A useful list for French publications is *Biblio ;* for Italian, the *Bollettino bibliografico mensile ;* for German, the *Deutsche Nationbibliographie.*

Once the existence of papers in scientific journals has been established they have to be obtained, frequently in photostat or microfilm form. Six lists which are useful in locating periodicals are :—*List of serials*, 1950, published by the United States Department of Agriculture Library ; the *Short-title catalogue of serials currently received by the Science Museum Library*, 1950 ; the *Catalogue des périodiques possédés par la Bibliothèque de l'Institut Internationale d'Agriculture*, published at Rome in 1946 ; *Périodiques reçus par la Section Technique d'Agriculture Tropicale* of the Ministère de la France d'Outre-Mer, which appeared in *L'agronomie tropicale*, Vol. II, Nos. 7-8, 1947, and comprises titles, publication addresses and prices of 115 French and 172 other periodicals ; *the World list of scientific periodicals* published in the years 1900–1933, a new edition of which is now being prepared ; and, for older British material, *Agricultural periodicals of the British Isles*, 1681–1900, *and their location*, compiled at the School of Agriculture, Cambridge, and published in 1951.

The notes that follow do not pretend to be a complete record of literary resources in the subjects concerned ; they are given to draw attention to certain specialized publications which although well known to librarians are probably less well known to scientific workers who have no need to refer to them frequently.

Botany

A guide to the bibliographies themselves has been provided by the Science Museum Library in its *Bibliographies on pure and applied botany and related subjects* (Bibliographical series, No. 144), published in 1934.

Abstract journals are *Botanisches Zentralblatt* (1880–1944) and *Botanical Abstracts* (1918–1926).

For old and elderly material, reliance will be placed upon the catalogue of the British Museum (Natural History) and G. A. Pritzel's *Thesaurus literaturae botanicae*, a reprint of which was issued in 1949.

Although not a bibliography, the *Index Kewensis* with its supplements is, of course, invaluable.

Also important are the sixteen volumes of the United States Department of Agriculture's *Botany current literature*, 1919–1934, and the printed cards comprising a bibliography of botanical literature from 1907 to 1947 of the Torrey Botanical Club, New York. (A set of these is available in India at the New Delhi Research Institute.) The Torrey Botanical Club also publishes an *Index to American botanical literature ;* it appears bi-monthly in *Bulletin of the Torrey Botanical Club* which is prepared in the Arnold Arboretum, Harvard University.

Readers' guide to books on botany, issued in 1951 by the County Libraries Section of the Library Association (Readers' guide, new series No. 11) is of interest mainly in the British Isles.

For the Far East, the *Bibliography of Eastern Asiatic botany*, 1938, by E. D. Merrill and E. H. Walker, is valuable.

Recent mycological literature is covered by four Commonwealth (formerly Imperial) Mycological Institute publications, *Bibliography of systematic mycology*, 1943–1946, *Bibliography of systematic mycology*, 1947, and *Bibliography of systematic mycology*, 1948, and the monthly journal *Review of applied mycology*. To these might be added another journal, *Revue de mycologie*, and the *Encyclopédie mycologique* which is to be complete in twenty volumes. (At the time of writing fourteen volumes have been published (1931–1951), volumes 15 to 19 are in the press and volume 20 is in preparation.)

Plant pathology in general is covered with great thoroughness by the United States Department of Agriculture's *Bibliography of plant pathology in the tropics and Latin America* (Bibliographical bulletin No. 14), compiled by H. V. Barnes and J. M. Allen and published in 1951 ; this comprises 2,395 references in alphabetical order of authors' names, with an index of joint authors and an index of plant diseases.

Also from the United States Department of Agriculture is the *Index of plant diseases in the United States* which supersedes the 1926 *Check list of diseases of economic plants of the United States*. Part I of the *Index* covers Acanthaceae— Compositae ; Part II, Convolvulaceae—Gnetaceae ; Part III, Gramineae. All three parts were published in 1950.

C. Moreau's *Les maladies parasitaires des principales cultures coloniales : revue bibliographique, VII*, which appeared in the *Supplement coloniale* of the *Revue de mycologie* in 1951, is an up-to-date list ; and there is a 95-page bibliography in E. A. Bessey's *Morphology and taxonomy of fungi*, 1950.

Abstract journals for plant pathology and plant protection are *Bibliographie der Pflanzenschutzliteratur*, 1914–1939, which appeared between 1921 and 1944; *Zeitschrift fur Pflanzenkrankheiten* (*Pflanzenpathologie*) *und Pflanzenschutz*, published from 1891 onwards ; and the appropriate abstract journals of the Commonwealth Agricultural Bureaux.

Floras.

The standard guide is *Geographical guide to the floras of the world*, by S. F. Blake and A. C. Atwood, published in 1942 as United States Department of Agriculture Miscellaneous publication No. 401.

A most valuable list of African floras, compiled by H. Jacques-Felix and entitled *Les flores d'Afrique tropicale* appeared in *L'agronomie tropicale*, Nos. 3–4, 7–8, 11–12, 1950. This covers French, Belgian, British, German, Portuguese and Spanish publications. It may be extended, perhaps, by addition of the following :—

Kennedy, J. D. *Forest flora of Southern Nigeria.* 1936.

Trochain, J. *Vegetation du Senegal.* 1942.

Glover, P. E. *A provisional check-list of British and Italian Somaliland trees, shrubs and herbs.* 1947.

Institut National pour l'Etude Agronomique du Congo Belge. *Flore du Congo Belge et du Ruanda-Urundi, preparée par le Comité Exécutif de la Flore du Congo Belge et le Jardin Botanique de l'Etat. Spermatophytes.* 2 vols. 1948 and 1951.

Lebrun, J., Taton, A. and Toussaint, L. *Contributions à l'Etude de la flore du Parc National de la Kagera.* 1948.

Andrews, F. W. *Flowering plants of the Anglo-Egyptian Sudan.* Vol. I. (It is understood that this will be completed in either three or four volumes. To accompany vol. I a separate work entitled *Vernacular names of plants as described in "Flowering plants of the Anglo-Egyptian Sudan, Vol. I"* was issued in 1948.) 1950.

Maire, R. *Flore de l'Afrique du Nord* (*Maroc, Algérie, Tunisie, Tripolitaine, Cyrenaique et Sahara*). Fasc. I. 1951.

Three other items may be noted.

The American Institute of Crop Ecology, at Washington, is issuing a series of twenty-two studies, entitled the *International agro-climatological series*, which deal with physical and plant geography in certain countries in Africa, Asia and Europe. The Instituto Agronomico do Norte, Belem, Brazil,

has begun publication of a series entitled *Notas sobre a flora neotropica.* And a new work by H. Jacques-Felix, entitled *Flore agrostologique illustrée de l'Afrique tropicale* was announced for 1950. (It is not known if this has actually been published.)

Entomology

Two helpful guides to the literature of entomology are both American.

R. C. Smith's *Guide to the literature of the zoological sciences,* 1945, is now out-of-print and difficult to obtain. It contains chapters on the following:— The literature problem of the scientist ; the mechanics of the library and book classifications ; bibliographies of the zoological sciences ; abstract journals ; the form of bibliographies ; the forms of literature ; preparation of a scientific paper ; taxonomic indexes and literature.

Covering some of the same ground, but limited to entomology, is W. J. Chamberlin's *Entomological nomenclature and literature,* 1945. The author remarks : " Literature is, of course, the basis from which all present-day workers get their inspiration, and the literature in the field of entomology is so extensive that one must handle it in a systematic manner."

The above-mentioned two works are guides to standard books and bibliographies.

Indispensable guides to recent entomological literature published in all countries are part *Insecta* of the *Zoological Record,* which has been published annually since 1864, and the two series of the Commonwealth Institute of Entomology's monthly journal *The review of applied entomology.*

Earlier literature than that recorded in the *Zoological Record* is listed in *Index literaturae entomologicae,* compiled by H. A. Hagen, W. Horn and S. Schenkling, which cites more than 25,000 titles and is said to include practically all articles on entomology published up to and including 1863. It appeared in four parts, the last in 1929.

What Chamberlin calls "probably the most valuable work on American economic entomology " is the *Bibliography of American economic entomology,* compiled by S. Henshaw and N. Banks, and published in eight parts, 1889–1895. This is continued as the *Index to literature of American economic entomology,* by N. Banks, M. Colcord and others and published in six volumes, 1905-1939.

Recent books which include extensive bibliographies are P. Lepesme's *Les insectes des palmiers,* 1947. which has a list of over 900 items, and W. Ebeling's *Subtropical entomology,* 1950, which has over 1,000.

Two other items should be mentioned. In 1946 the Institut Sanidad Vegetal of Buenos Aires published *Bibliografia entomologica Argentina,* compiled by A. A. Piran ; and in 1950, as volume I, No. 3, of the new *Bulletin of the British Museum (Natural History), Entomology series,* there appeared *The early literature of Mallophaga* (Part I), by T. Clay and G. H. E. Hopkins.

Bibliographies of literature concerning insecticides may be found in *Chemistry of insecticides, fungicides and herbicides,* 1948, by D. E. H. Frear ; *DDT and newer persistent insecticides,* 1950, by T. F. West and G. A. Campbell ; *Chemistry and uses of insecticides,* 1948, by E. R. De Ong ; *Chemistry and*

action of insecticides, 1951, by A. H. Shephard ; and *Insect control by chemicals*, 1951, by A. W. A. Brown. United States reports not available in printed form from other sources are listed in *Special bibliography of reports on insecticides and rodenticides*, 1950, issued by the United States Department of Commerce.

In the field of nomenclature, as distinct from bibliography, it is perhaps worth mentioning that volume five of *Nomenclator zoologicus*, edited by S. A. Neave, was published in 1950. This new volume "attempts to include all generic names in zoological literature, over 18,000 in number, between the years 1936 and 1945 inclusive, together with a few hundred names omitted previously." Publication of a further volume every ten years is intended for the future.

Crops

A bibliography of almost any crop may be compiled from the six volumes of the *Bibliography of soil science, fertilizers and general agronomy*, and from such other Commonwealth Agricultural Bureaux publications as *Field crop abstracts* and *Horticultural abstracts*, and the American *Biological abstracts* and *Bibliography of agriculture*. Certain major crops have received more attention from bibliographers than others; we list titles concerning a few of them.

Cotton.

Current literature is analysed in *The Empire cotton growing review*, the British Cotton Industry Research Association's fortnightly *Summary of current literature*, and in the *Bulletin analytique* which is issued as a supplement to *Coton et fibres tropicales*. (The last-mentioned now includes over six hundred abstracts a year concerning cotton and other fibres.) Literature covering the years 1931–1942 is recorded in the twelve volumes of *Cotton literature : selected references prepared in the Library of the United States Department of Agriculture, Washington*, and some older material may be traced in *The genetics, breeding and improvement of corn and cotton : a bibliography covering more than forty years work* (1889–1929) *in the breeding, improvement, and study of inheritance in corn and cotton*, by C. K. McClelland, published in 1930 ; and in the Indian Central Cotton Committee's *Index to publications of the Imperial Department of Agriculture in India dealing with cotton*— 1906–1926, published in 1927. The most up-to-date monograph on cotton, *Cotton production, marketing and utilization*, 1950, edited by W. B. Andrews, gives a great many references to recent literature, while another standard work, H. B. Brown's *Cotton : history, species, varieties, morphology, breeding, culture, diseases, marketing and uses*, 1938, also lists publications dealing with this crop.

Cereals.

The Imperial Bureau of Plant Genetics, Cambridge, in its early days, issued the following :—

Wheat-breeding bibliography, 2 parts. (No date).

Addenda to wheat-breeding bibliography. (No date).

Oat breeding bibliography. (No date).
Barley breeding bibliography. 1930
Rice breeding bibliography. 1931.
Rye breeding bibliography. 1932.

Bibliography on the breeding and genetics of the millets and sorghums. 1932.

Other useful works are the *Bibliography of world literature on the genetics and breeding of wheat*, issued by the Institute of Plant Industry, Lenin Academy of Agricultural Sciences, 1935 ; J. C. Cunningham's *Maize bibliography for the years* 1917–1936, *inclusive*, issued by the Iowa Research Institute in 1941 ; *A bibliography of cerealiana*, 1938, by C. H. Briggs ; and the bibliographies in the U.S.D.A. publication *Identification, history and distribution of common sorghum varieties*, 1936, by H. N. Vinall, J. C. Stephens and J. H. Martin, and *Cultivated races of sorghum*, by J. D. Snowden, 1936. Mainly of nutritional interest are :—

Bibliographie concernant les matières proteiques des riz. (*L'agronomie tropicale*, vol. III, Nos. 9–10, 1948).

Bibliographie concernant les vitamines du riz. (*L'agronomie tropicale*, vol. IV, Nos. 7–8, 1949).

The most up-to-date bibliographies on rice are the list of 240 references contained in *Le riz: étude botanique, genetique, physiologique, agrologique et technologique appliquée a l'Indochine* (Archives de l'Office Indochinois du Riz, No. 30), by Y. Coyaud, 1950, and *Rice during and after the war : a bibliography of the literature on rice during the period* 1940–1947, compiled by L. W. Kuilman, published at Buitenzorg in 1949.

Sugar.

Two useful bibliographies became available in 1947. M. W. Rowley's 19-page *Sugar: cultivation, industry, machinery, &c.* is one of the Bibliographical series issued by the Cape Town School of Librarianship. *The sugar industry of the Caribbean* was published by the Caribbean Research Council and contains a 67-page bibliography. Ten years older is C. R. Bitting's *Bibliography on sugar* which was " prepared on behalf of Everglades sugar producers and those who desire to produce sugar there ". Insect pests are covered by J. S. Wade's *A selected bibliography of the insects of the world associated with sugar cane, their predators and parasites*, published in 1951 by the International Society of Sugar Cane Technologists at Honolulu. In addition, concerning a by-product, there is *The utilization of sugar-cane bagasse for paper, board, plastics and chemicals : an annotated bibliography*, published by the Sugar Research Foundation in 1949.

Tobacco.

The most up-to-date work is the *Select list of books and pamphlets on the tobacco industry*, issued in 1948 as Bibliographical series No. 652, by the Science Museum Library. A good bibliography also exists in *The production of tobacco*, 1946, by W. W. Garner. Earlier compilations are J. Lorca's *Bibliografia sobre fitotecnia del tabacco*, issued in 1942 by the Instituto Nacional del Tabacco at Buenos Aires, and the *Tobacco breeding bibliography* issued in 1937 by the Imperial Bureau of Plant Genetics.

Miscellaneous crops.

United States Department of Agriculture. *Agronomy current literature.* 1926–1934. 9 volumes.

Crane, J. C. and Greene, L. *Abstracts of some of the literature pertaining to coffee.* 1948. (Issued by U.S.D.A.).

Imperial Bureau of Soil Science. *Bibliography of publications relating to coffee soils and fertilizers.* 1934.

Imperial Bureau of Soil Science. *Sisal bibliography.* 1932.

Moreau, R.E. *An annotated bibliography of cinchona growing from* 1883–1943. 1945.

Moreau, R. E. *Derris agronomy : an annotated bibliography and a critical review.* (*East African agricultural journal,* vol. X, No. 4, 1944).

Shaw, F. J. F. and Rakhal Das Bose. *List of publications on the botany of Indian crops.* 1930. (This is Bulletin 202 of the Imperial Institute of Agricultural Research, Pusa, and covers the period 1917–1927. Its chapters deal with cereals, legumes, oil seeds, fibres, money crops (including cotton, sugar cane and tobacco), and miscellaneous publications, including those on fodders and sunflowers.)

Morris, J. N. and Dollear, F. G. *Abstract bibliography of the chemistry and technology of peanuts,* 1830–1939. 1949.

Watrous, R. C. *Cacao : a bibliography on the plant and its culture and primary processing of the bean.* (U.S.D.A.). 1950.

Von Wolf Mueller. *Bibliographie des kakao.* Gordian, Hamburg. 1951.

Bernstein, E. H. *Farming in Southern Rhodesia : a bibliography.* (One of the Bibliographical series issued by Cape Town School of Librarianship). 1949.

Plant Nutrition

Useful bibliographies are given in *Water in the physiology of plants,* 1949, by A. S. Crafts, H. B. Currier and C. R. Stocking ; *Plant and soil water relationships,* 1949, by P. J. Kramer ; and *Growth substances and their practical importance in horticulture,* 1948, by H. L. Pearse.

Abstracts appear in several of the Commonwealth Agricultural Bureaux journals.

In addition, the following are very thorough compilations concerning particular aspects of nutrition :—

Iodine and plant life : annotated bibliography, 1813–1949, issued by the Chilean Iodine Educational Bureau in London, 1950.

Bibliography of the literature on the minor elements and their relation to plant and animal nutrition, Vol. I, issued by the Chilean Nitrate Educational Bureau, Inc., 1948. (This has over 1,000 pages). Vol. II was published in 1951.

Bibliography of the literature of sodium and iodine in relation to plant and animal nutrition, issued by the Chilean Nitrate Educational Bureau, Inc., 1948.

The most important publications have already been mentioned. They are :—

Bibliography of soil science, fertilizers and general agronomy, covering 1930–1950, published in six volumes by the Commonwealth Bureau of Soil Science, Harpenden.

Soils and fertilizers, the bi-monthly abstract journal.

Chemical Abstracts, published since 1907.

British Abstracts (formerly *British chemical abstracts* and *British chemical and physiological abstracts*), published since 1926.

To these may be added :—

Bodenkundige Bibliografie. 1947.

Chemisches Zentralblatt, published since 1930.

Gough, H. C. *A review of the literature on soil insecticides.* 1945.

Literatursammlung aus dem Gesamtgebiet der Agrikulturchemie. Bd. I–V. 1931–39.

Useful general guides to the great mass of literature on chemistry are *A short guide to chemical literature*, 1951, by G. M. Dyson, and *German books on chemical and cognate subjects published* 1939–1950, 1951, by A. E. Cummins and S. Vince.

Certain important subjects, such as animal husbandry, veterinary science, forestry, horticulture, meteorology, agricultural economics, genetics, fruit-growing, and microbiology, have been omitted for the most part from the foregoing survey. (Perhaps some better qualified writer will deal with their bibliography ?). It is hoped, however, that enough information has been given to indicate that a solid basis of literature does exist for facilitation of research in agriculture and its supporting sciences. Many specialized bibliographies published by the Commonwealth Agricultural Bureaux, the United States Department of Agriculture, and UNESCO, have been omitted for the sake of brevity ; references to them may be found in the general bibliographies of bibliographies compiled by Besterman, and Bohatta and Hodes, either of which may well be used as a guide to the whole field under review.

Useful directories to further sources of information concerning subjects dealt with here and those omitted are the *International directory of agricultural libraries and of libraries specialized in subjects related to agriculture*, issued by the International Institute of Agriculture, at Rome, in 1939 ; *Agriculture and allied interests*, which was No. 2 of the ASLIB *Guides to sources of information in Great Britain*, published in 1949; and the section relating to agriculture of the UNESCO *Directory of international scientific organizations*, 1950.

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BIBLIOGRAPHY OF CACAO

Bibliographie des Kakao BY VAN WOLF MUELLER. *Published by Gordian, Hamburg*, 1951. *Price* 15*s.* 8*d.*

THERE has, for some time, been a general demand for an extensive and up-to-date bibliography of cacao literature. This has been accentuated by the greatly increased interest in cacao manifested in recent years partly as a result of the fear of diminishing supplies of cacao due to disease and neglect of plantations during a prolonged period of low prices.

As frequently happens in such cases the need for a comprehensive bibliography has now been met by two independent sources. In October 1950 the United States Department of Agriculture published Library List No. 53 which consists of a bibliography of the cacao plant and its culture and primary processing of the bean compiled by Roberta C. Watrous. This has now been supplemented by the bibliography under review, which is considerably more comprehensive in scope than Library List No. 53 of the U.S.D.A. claims to be. In particular the compiler, Dr. Wolf Mueller has included a comprehensive bibliography of historical material in the first section—this material was collected over a period of twenty years for use in an authentic " History of Cocoa and Chocolate ", the publication of which is now pending.

To the research worker the classification of material in the American bibliography will probably be found more convenient but the German publication also uses a comprehensive system of cross-reference and although a little more tedious to use, probably reduces the chances of missing important papers.

It is rather unfortunate that the only index reference to the Imperial College of Tropical Agriculture is incorrect but this does not mean that the work carried out in the College has not been covered in detail.

The Editor of the bibliography has appealed to all cacao workers to bring to his notice any errors which may have occurred and to co-operate in making the bibliography as complete as possible by sending reprints of published material.

It is to be hoped that all cacao workers will, in their own interest, co-operate in this manner.—H.E.

COMMUNICATIONS ON ORIGINAL INVESTIGATIONS

ABNORMAL ROOTS IN OIL PALMS IN THE BELGIAN CONGO

BY

W. G. KOVACHICH

(*Plant Pathologist, Research Department, Huilever S.A., Leopoldville*).

Introduction

This paper is an initial contribution to investigations of the diseases of the oil palm, in which abnormal root growth and disease are important features. Mention of abnormal roots in oil palms (*Elaeis guineensis*) affected by the disease known as Plant Failure was made by Wardlaw (1946). He described the affected roots as showing . . . " a slow inhibited growth with a paucity of laterals " and suggested that the abnormal root development might be interpreted " as a correlation condition referable to the abnormal metabolism of the affected leaves ". Devuyst (1949) observed that the young roots of palms with Bud Rot disease were abnormal in that they showed an arrested or inhibited condition. In the Belgian Congo, abnormal roots, which may include arrested, rotted and constricted roots, are found in palms affected by any of the following diseases : Vascular Wilt, Bud Rot, Plant Failure, Patch Yellow, Ganoderma Trunk Rot, Leaf Bend and various types of Chlorosis ; they are also frequently observed in apparently healthy palms.

Arrested Roots

Roots in this category are defined by the writer as roots which have had their growth completely arrested, a hard, non-elastic layer of tissue having formed over the root tips. This covering is continuous with the hard outer layer of the mature parts of the root. Such root tips are easily identifiable as they are, according to the age at which this abnormal development has taken place, brown or grey-black coloured instead of the ivory white colour of healthy root tips. The root endings are either rounded or sharply conical as compared with the gently pointed tips of normal roots. The lateral roots also usually lack healthy tips, and their fine absorbing rootlets are generally of an unhealthy yellow-brown colour.

During the inception of this abnormal development, the growth rate of the root is greatly reduced and the brown colour of the more mature parts of the root rapidly replaces the ivory-white colour of the tip and root-cap. At this stage, the growth of the root is completely arrested. Later, this brown colour is replaced by the grey-black colour of the older parts of the root.

The stele in arrested roots is of a darker colour than normal and is extremely woody, even in the region of the tip. The inner cortical cells and the cells of the pith of young affected roots are commonly a dull, diffuse red colour and the stele is easily separated from the cortex. Other changes include the replacement of the exodermis of the root-tip by a hypodermis and the thickening and suberisation of the walls of the outer cortex. The formation of this hard layer frequently leads to the loss of the root-cap. Where the latter remains attached to the root tip the outer cells become suberised whilst the remaining cells shrink and die. Where the root-cap is lost the root tip is rounded but if the root cap is present the ending is sharply conical. These anatomical and colour changes are identical to those which take place during the maturation of a healthy root, but whereas a healthy root maintains an ivory-white growing tip, the growth in anomalous roots is inhibited and no young tissue is formed.

In these anomalous roots, occasional recovery takes place by one of two methods. The more common method is for a lateral branch or branches to be formed directly behind the affected root tip. Where the recovery is complete, these branches assume the functions of the main root. However, they too commonly become affected, and, in turn, may produce a second series of branches. The sequence of recovery and arrest often continues over a considerable period and results in roots which terminate in a clump of short, arrested branches. This type of root ending is commonly observed in the root systems of Plant Failure, Vascular Wilt and Leaf Bend diseased palms. Other roots recover by resuming growth along the original axis. The resumption of growth ruptures the hard layer covering the root-tip and a new root-cap is formed. The ivory-white root tip is sharply differentiated from the adjacent brown or grey black tissue. Some roots show a series of slight constrictions which denote the number of times growth has been renewed after a temporary arrest.

Cultures of arrested root-tips have not yielded any micro-organisms, a result that was confirmed by microscopical examination. Thus it would appear that the abnormal condition of roots is referable to some abnormal physiological condition in the palm, a view for which support has been obtained in a study of the leaf disease known as Patch Yellow. The writer has proved that this disease is caused by *Fusarium oxysporum* and that the infection is restricted to the leaves. The roots of mildly infected palms are comparable to those of healthy palms but in palms with a severe infection the majority of the roots are abnormal and arrested. This evidence suggests a correlation between root development and the health or growth status of leaves. In order to test this hypothesis, twelve healthy, six-year-old palms were selected. Six were left as controls whilst in the remaining six all excepting the distal leaflets were removed from all of the opened leaves. One treated and one control palm were uprooted for examination after an interval of one month, the remainder being similarly examined after two months. All of the root tips within 50 cms of the base of the trunk were collected, classified and counted. The results of this experiment are tabulated in Table 1.

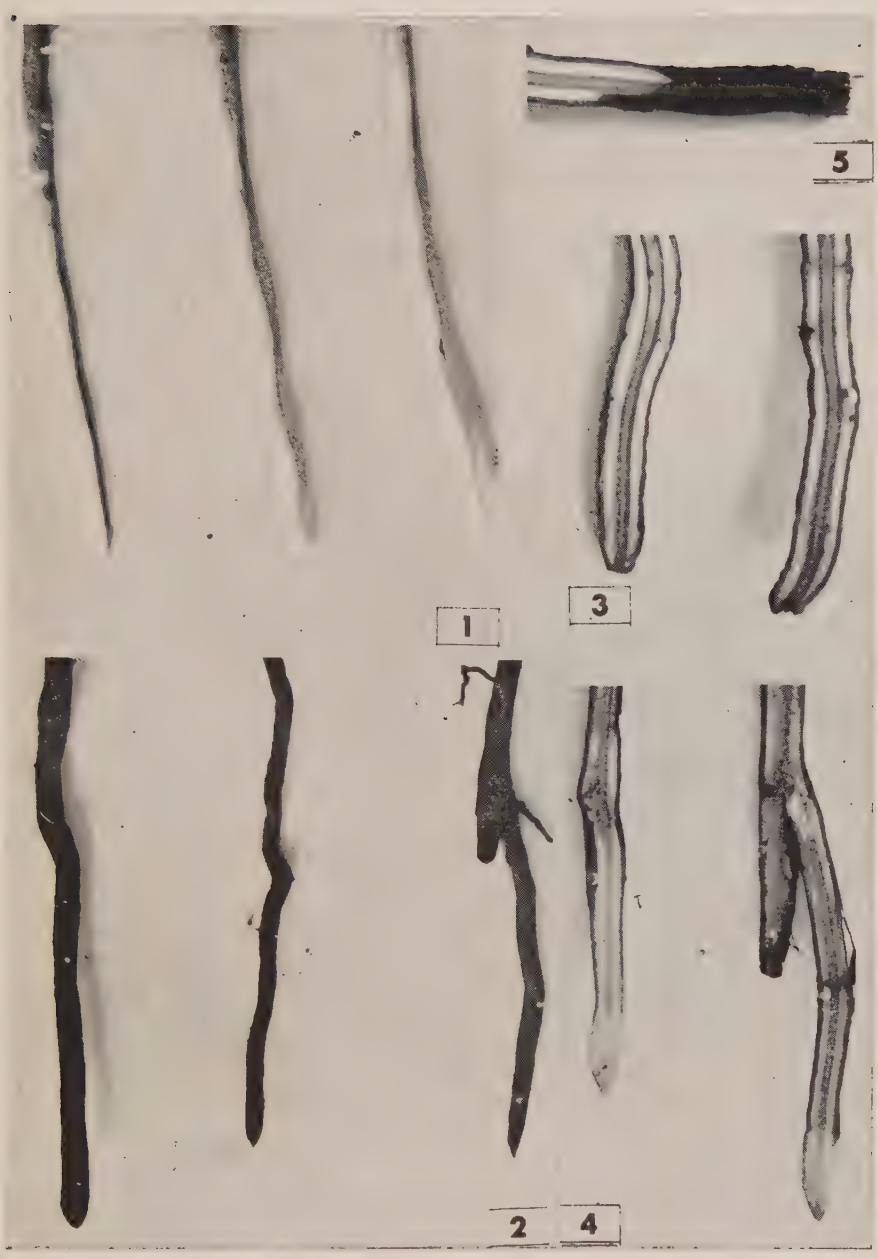

Fig. 1. Healthy root tips.
Fig. 2. Arrested root tips.
Fig. 3. Longitudinal section of arrested roots.
Fig. 4. Roots recovered after being arrested.
Fig. 5. Rotted root.

TABLE 1

Root changes resulting from the removal of the pinnae from the leaves of healthy palms.

Months After treatment	Treated Palms		Control Palms	
	Arrested roots	Normal roots	Arrested roots	Normal roots
1	24	13	0	49
2	59	0	11	35
2	19	1	0	12
2	33	0	1	35
2	15	0	4	16
2	18	0	3	64

The data of this experiment show that there is a correlation between leaf activity and root formation in the oil palm. Furthermore, in palms affected by Plant Failure, Patch Yellow and Vascular Wilt the percentage of arrested roots increases as the damage to the fronds increases. Leaf injury, however, cannot be accepted as the sole cause of abnormal root development, e.g., the roots of Bud-Rot palms are abnormal before the appearance of any disease or necrosis of the fronds.

Abnormal, arrested roots have also been observed in the roots of bananas (*Musa sp.*) and raffia palms (*Raphia vinifera*).

Rotted Roots

Severely diseased oil palms almost invariably possess numerous rotted roots. Specific fungi, e.g. *Fusarim oxysporum* (Vascular Wilt), *Armillaria mellea* (Armillaria Trunk Rot) and *Ganoderma lucidum* (Ganoderma Trunk Rot), are associated with certain types of root rot, although the extent to which these fungi are responsible for the rotting is not known. Other rotted roots, i.e. those observed in Plant Failure, Bud Rot, Patch Yellow and Chlorotic palms, do not appear to be related to the activity of any one fungus, bacterium or eel worm. The following account is confined to the latter forms of rotted roots.

All of the roots examined which showed early symptoms of rotting were either completely arrested or were in a late stage of so becoming. Usually the rot first appeared as a slight translucency of the tissues of the root-cap and tip of the root immediately before the arrest of root growth had been completed. The affected tissues rapidly became brown coloured, moist and badly rotted. This rot was occasionally sealed off from the rest of the root by a callus layer. Completely arrested roots were also commonly rotted, the rot first appearing as yellow-brown isolated patches directly below the suberised layer of the outer cortex. These patches increased in size and became a dark brown colour, but occasionally, the spread of this rot was prevented by the formation of a callus layer. If the rot was not arrested, the whole of the non-suberised part of the cortex became decayed and this was followed by the rotting of the stele. Badly rotted roots had their root tips completely destroyed and the distal ends of the roots consisted of an empty cylinder composed of the hypodermis and the thick walled, suberised cells of the outer cortex.

When material from rotted roots was cultured, many fungi were isolated, but a single fungus was rarely consistently isolated from the rotted roots of a single palm. Microscopical examination of sections of rotted roots have shown the presence of mycelium in the hypodermal cells, cortex and stele. The early rotting of the tissues was occasionally observed to occur in advance of the entry of mycelium into the cortex. Eel worms were commonly present in the badly rotted tissues.

A tentative explanation of the prevalence of root rotting is that normal root growth is arrested as a result of a physiological disturbance in the palm, the roots thereby being rendered susceptible to infection by weakly parasitic micro-organisms. The susceptibility of weak roots to a rot has been observed by cutting the roots of robust and unthrifty disease free palms: whereas the former were stimulated to produce numerous healthy branches which were well supplied with absorbing rootlets, the latter became rotted.

Constricted Roots

Constricted roots have been observed in association with Leaf Bend, Vascular Wilt, Chlorotic and Healthy palms. The constrictions, approximately 1 cm. long, are commonly found at intervals of 4-8 cms. along the root, the superficial tissues in the affected parts being more brittle than normal. Relatively few constricted roots were found in any one palm. Other roots were observed which possessed a dark brown band round the otherwise healthy root tips. These roots were considered to display early symptoms of the abnormal development. The ivory white parts of these root tips were histologically normal, i.e., with unthickened walls in the outer cortex and a small celled hypodermal layer. But in the zone of the brown band, the outer cells of the cortex possessed thickened walls and the cells of the hypodermal layer were enlarged and discoloured. No micro-organism has been found in association with these abnormal roots. The mechanism of constriction appears to be that the outer layer of the root prematurely hardens in a limited band directly behind the growing point and prevents the normal enlargement of the cells within.

The Relationship between Diseased Roots and Leaf Symptoms

The present investigation has shown that abnormal leaf conditions are involved in the development of abnormal and diseased roots (Patch Yellow and the experimental removal of the leaflets), but it is not yet known how and to what extent diseased roots affect the condition of the leaves. A root survey of healthy palms and palms with various diseases was carried out during 1950. The palms were first uprooted by cutting the roots 50 cms. from the base of the trunk, the attached roots being then severed from the trunk and examined. A trench, 2m. x 1m. x 1m., was then dug radially from the site of the palm and all root materials from this trench were collected and examined. These materials were separated into pieces with and without root tips, the former being classified as healthy, arrested or rotted and the latter as healthy or rotted, Table 2.

TABLE 2

The incidence of abnormal and diseased roots in variously diseased oil palms.

Disease	Young Roots with Root Tips (0–50 cms.)			Old Roots (50–250 cms.) Tips		Old Roots (50–250 cms.) Pieces	
	Healthy	Arrested	Rotted	Healthy	Arrested	Healthy	Rotted
Vascular Wilt ...	5	336	570	1	2	145	251
	1	64	675	1	1	185	148
	15	24	511	2	1	236	318
	17	62	121	3	4	293	118
Average percentage Healthy		1.6			50.6		
Bud Rot ...	0	4	0	0	2	154	4
	0	0	55	0	0	127	41
	0	209	15	0	0	367	29
	0	35	4	0	4	104	1
Average percentage Healthy		0			91.5		
Plant Failure ...	5	216	17	7	18	231	51
	2	3	0	0	0	49	82
	0	28	65	0	0	52	120
	0	21	114	1	2	67	11
Average percentage Healthy		1.5			58.9		
Chlorosis ...	38	121	21	4	1	477	108
	88	362	0	0	7	124	16
	0	15	17	0	0	208	32
Average percentage Healthy		17.5			75.3		
Patch Yellow ...	0	42	5	0	1	193	5
	0	156	0	0	3	317	14
Average percentage Healthy		0			95.6		
Leaf Bend ...	5	1,214	3	6	8	763	3
	63	728	0	9	6	681	8
Average percentage Healthy		3.3			98.1		
Healthy Palms ...	147	6	0	7	1	280	35
	9	13	9	10	4	197	2
	167	88	6	22	11	446	32
	28	12	2	6	0	150	5
Average percentage Healthy		72.1			92.5		

From these data it will be seen that in palms severely affected by Bud Rot, Patch Yellow, Plant Failure, Vascular Wilt and Leaf Bend many of the young roots are either abnormal or diseased. The young, opened leaves of these palms, with the exception of those with Leaf Bend, are typically more erect than normal, even when they are otherwise apparently healthy. (Leaf Bend only affects very old palms and the inner leaves are not normally erect but the old fronds are bent downwards). The old roots are most severely affected in Vascular Wilt and Plant Failure cases. The erect habit of the older leaves is an external symptom which is characteristic of young palms with these diseases. Thus, in general, the conditions of the young roots is reflected in the habit of the young leaves while erect old leaves are associated with badly diseased old roots. These findings do not, however, hold good for palms of more than fourteen years of age. Observations have shown that, apart from Plant Failure palms, wilting of the old leaves is a more common disease symptom with old palms than the erect habit of the leaves. On the other hand, many young palms with a heavy infection of Patch Yellow possess erect outer leaves although the old roots are not severely diseased. The erect habit of the leaves apparently results from a physiological disturbance within the palm. Clearly the relationship between leaf habit and disease and root development and disease merits further investigation.

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THE GERMINATION OF BANANA SEEDS

By

N. W. SIMMONDS

(*Senior Cytogeneticist, Banana Research Scheme, Imperial College of Tropical Agriculture, Trinidad*).

Summary

Experiments on factors affecting the germination of banana seeds are described. Seeds should be extracted from mature, ripe fruits ; they should be well cleaned and stored, if necessary, in a desiccator, though viability may be retained for about six months simply by drying in the sun. In the greenhouse free drainage is very important. Pre-sowing treatments such as soaking in sulphuric acid, chipping of the testa, soaking in water, scorching, and the application of temperature shocks are usually deleterious and often lethal. Results are discussed in relation to the needs of experimental technique and of a banana collecting expedition.

1. Introduction

Knowledge of factors affecting the germination of banana seeds is needed for the proper understanding and effective execution of experimental and breeding procedures ; and it is needed to guide the technique of collection of wild bananas for use in the research scheme. It is also needed for an understanding of the ecology of the banana but the experiments reported here have little bearing on this subject and will not be considered in that connection.

I am much indebted to Dr. D. J. Finney for helpful discussion of statistical problems.

2. Materials and Methods

All tests were carried out with seed of one or both of the two most important species of Eumusa, *M. acuminata* and *M. Balbisiana*. Some of the seed was the product of controlled self-pollination ; the rest originated from open-pollination but must often have also been the product of selfing.

Experiments were factorial and were based on tests of 50 seeds per plot. The medium in which the seeds were sown varied with the demands of the experiment. When sowing media were not actually under test, boxes of greenhouse soil or pots of sand were used (see Experiment XIV) ; the latter had the advantage that when seeds were sown over a period of weeks (or even years) fairly uniform sowing conditions could be obtained—which was not the case when a greenhouse soil had either to be left unused for a time or else mixed afresh. Germinations were recorded for from two to four months ; virtually all occurred in the first two months.

Data were reduced to percentages (and are so summarized here) but for statistical analysis were transformed to angles. This procedure equalizes the variance of different transformed means ; the error variance, in fact, should theoretically depend only on the number in the sample and in these experiments, with n = 50, should be about 16. This was rarely achieved and in many cases the error variance was 30–40. This means that absolutely uniform conditions of treatment or sowing were not achieved. When, as happened several times, germinations were very high or very low purely statistical troubles arose ; with percentages of over 95 per cent. or under 5 per cent. in 10 per cent. or more of the plots, formal analysis becomes risky. Sometimes a whole treatment could be rejected. Sometimes analysis was impossible ; but then the results were often obvious.

Significance of a variance ratio is indicated by the following conventions :
*—5% ; **—1% ; ***—0.1 %.

3. Results

A. *Internal factors—the state of the bunch.*

Experiment I. There were sixteen (2 x 2 x 2 x 2) treatments each replicated once. Treatments were :—

M. acuminata versus M. Balbisiana

Bunch immature (about 3 weeks before fullness) *versus* bunch mature.

Seeds from unripe fingers *versus* seeds from ripe fingers.

Seeds sown fresh and wet *versus* seeds sown after drying in the sun and one week in the desiccator.

The bunch of *M. acuminata* was rather less mature than that of *M. Balbisiana* as judged by development subsequent to the first sampling—it is difficult to get two bunches coming to maturity at just the same time and judgement is made more difficult by inter-specific differences. Results are given in Table 1.

Table 1—*Experiment I. Ripeness, wetness and maturity in two species. Germination percent.*

		M. Balbisiana		*M. acuminata*	
		Immature	Mature	Immature	Mature
Wet	Ripe ...	48	39	16	20
	Unripe ...	14	16	0	13
Dry	Ripe ...	16	32	0	15
	Unripe ...	2	17	0	17

Seven out of thirty-two plots gave no germination so the following analysis of variance (angles) must be examined with some reserve.

Item	D.F.	M.S.	V.R.
Species	1	1161	48.0***
Wetness	1	530	21.9***
Ripeness	1	1072	44.3***
Maturity	1	1167	48.2***
SW	1	34	1.4
SR	1	175	7.2*
SM	1	260	10.7**
WR	1	199	8.2*
WM	1	382	15.8**
RM	1	141	5.8*
2nd and 3rd order †	5	140	—
Error	16	24	—

† None significant.

Conclusions are that *M. Balbisiana* germinated better than *M. acuminata;* that wet seeds germinated better than dry ; that seeds from ripe fruits germinated better than those from unripe ones; that mature fruits gave more viable seeds than immature ones. The interactions indicate that the species agreed in the effect of wetness but disagreed with regard to ripeness and maturity, *Balbisiana* benefiting more from ripeness and *acuminata* being more sensitive to immaturity. Seeds extracted from ripe fruits were more affected by wetness than those taken from unripe fruits and, similarly, seeds extracted from immature bunches benefited particularly by wetness, those from mature bunches showing little or no effect. Finally, if the bunch were mature, ripeness was of slight importance but if immature, ripeness had a large effect.

Experiment II. Musa acuminata. There were eight (2 x 4) treatments each replicated once :—

Seeds sown wet *versus* sun-dried for three days.

Fruits green *versus* fruits ripe *versus* fruits black-ripe (1 week after yellow-ripeness) *versus* fruits rotted (2 weeks after yellow-ripeness).

Results were :—

TABLE 2—*Experiment II. Ripeness of fruit and wetness of seed. Germination percent*

	Green	Yellow-ripe	Black-ripe	Rotted
Wet	83	86	59	53
Dried	95	87	73	42

Ripeness alone is significant ; any degree of blackening or rotting of the fruit is deleterious. Dried seeds are not at all inferior to wet ones in this experiment, in contrast with the finding of Experiment I.

Experiment III. M. Balbisiana. There were eleven treatments each replicated twice :—

Fruits taken at 6, 5, 4, 3, 2 and 1 week before maturity of the bunch, at maturity and at 1, 2, 3 and 4 weeks after maturity.

Fingers were ripened before extraction of the seeds. The earliest samples ripened slowly and unevenly ; those taken after maturity came from rotted fruits. Seeds were sown fresh and undried.

Results were :—

TABLE 3—*Experiment III. Maturity of bunch. Germination percent.*

Weeks before and after maturity										
—6	—5	—4	—3	—2	—1	0	+1	+2	+3	+4
35	55	87	92	91	96	97	89	82	46	51

Reaping at or just before maturity is important but some germination can be obtained over a wide range of time. *M. Balbisiana* seems to be less sensitive to rotting than *M. acuminata*, from a comparison of Experiments II and III.

B. Treatment of the seeds before sowing.

Experiment IV. M. Balbisiana. There were 12 (3 x 2 x 2) treatments each replicated once :—

Seeds not stored *versus* seeds stored in a desiccator for 3 months *versus* seeds stored in laboratory for 3 months.

Seeds soaked in water for 48 hours *versus* seeds unsoaked.

Seed coats chipped with a knife *versus* seed coats not chipped.

Results were :—

TABLE 4—*Experiment IV. Soaking, chipping and storage. Germination percent.*

		Not stored	Desiccator 3 months	Laboratory 3 months
Soaked	Chipped ...	2	0	1
	Not chipped ...	71	78	76
Unsoaked	Chipped ...	0	3	1
	Not chipped ...	81	70	83

Chipping is virtually lethal to the seeds ; soaking and storage had no detectable effects.

Experiment V. M. Balbisiana. There were 10 (5 x 2) treatments, once replicated :—

Seeds scorched *versus* seeds not scorched.

Seeds not soaked (1) *versus* seeds soaked for 2 days (2) *versus* seeds soaked and then dried for 2 days (3) *versus* seeds soaked and dried and soaked (4) *versus* seeds soaked, dried, soaked and dried (5).

Seeds were dry at the start of the experiment, having been kept in a desiccator for several months. Scorching was carried out in a cigarette tin of wood shavings ; the flame took about half a minute to die down and was sufficient just to tinge brown the testas. A few seeds burst.

Results were :—

TABLE 5—*Experiment V. Scorching and soaking. Germination percent.*

		Scorched	Not scorched
Soaking treatments	1	3	78
	2	0	75
	3	1	73
	4	2	59
	5	1	80

Scorching is virtually lethal. Soaking treatments were non-significant.

Experiment VI. M. Balbisiana and *M. acuminata.* There were sixteen treatments (4 x 2 x 2) once replicated :—

Seeds soaked for 0, 1, 2, 4 weeks in tubes of water.

Soaking in dark *versus* soaking in light.

M. Balbisiana versus M. acuminata.

Results were :—

TABLE 6—*Experiment VI. Soaking of seeds in dark and light in two species. Germination percent.*

		Weeks of soaking			
		0	1	2	4
M. Balbisiana	Light ...	84	78	60	73
	Dark ...	87	92	65	89
M. acuminata	Light ...	45	23	27	12
	Dark ...	42	23	24	26

The analysis of variance (angles) was :—

Item	D.F.	M.S.	V.R.
Species	1	8224	310.3***
Light	1	167	6.3*
Times	3	348	9.4**
SL	1	69	2.6
ST	3	165	6.2*
LT	3	62	2.3
SLT	3	9	—
Error	16	27	—

Soaking treatments were either ineffective or deleterious and the longer the period of soaking the more was germination reduced (in *M. acuminata* at least). Dark soaking was less deleterious than light soaking in both species. Seeds of *M. acuminata* were more damaged by prolonged soaking than those of *M. Balbisiana*. It will be noted that there is an apparently anomalous drop in germination of *M. Balbisiana* at two weeks ; the cause is not known .

Experiment VII. M. Balbisiana. There were seven treatments, once replicated. Seeds were soaked in concentrated sulphuric acid for 0, 2, 4, 8, 16, 32 and 64 minutes, washed thoroughly and sown immediately.

Results were :—

TABLE 7.—*The effect of sulphuric acid on seeds of M. Balbisiana. Germination percent.*

Time (minutes)	Germination
0	52
2	64
4	57
8	35
16	15
32	0
64	0

Sulphuric acid is lethal if applied for 30 minutes or more ; it is deleterious or without effect for shorter periods. The month by month records of germination suggest that, apart from any effect on total germination obtained, sulphuric acid slows down the rate of germination, thus :—

TABLE 8.—*Effect of sulphuric acid on rate of germination. Percentage of total germination in successive months.*

Minutes	Month			
	1	2	3	4
0	96	98	98	100
2	86	92	92	100
4	72	84	88	100
8	71	89	89	100
16	67	87	87	100

Experiment VIII. M. Balbisiana. There were ten treatments (5 x 2) replicated once. Treatments were :—

Seeds wet *versus* seeds sun-dried.

Seeds kept at laboratory temperatures (ca. 30°C) *versus* seeds heated for 4 days in cytological oven (60°C) and returned to laboratory *versus* seeds chilled for 4 days in domestic refrigerator (ca. 10°C) and returned to laboratory *versus* seeds heated and then chilled for four days each *versus* seeds chilled and then heated for four days each.

Results were :—

TABLE 9—*Temperature shocks. Germination percent.*

	Laboratory	Oven and Laboratory	Frig. and Laboratory	Oven and Frig.	Frig. and Oven
Wet ...	98	0	92	0	0
Dry ...	100	60	96	4	16

Formal analysis is impossible but the results are obvious enough. Chilling did not harm the seeds appreciably but high temperatures did, especially if the seeds were wet.

Experiment IX. There were 24 treatments (3 x 2 x 2 x 2) each replicated once. Treatments were :—

M. acuminata versus M. Balbisiana.

Seeds dry (desiccator) *versus* seeds wet.

Seeds stored in laboratory (ca. 30°C) *versus* seeds cooled in domestic refrigerator (ca. 10°C) *versus* seeds frozen (0°C).

Treatments carried out for 2 *versus* 7 days.

Results were :—

TABLE 10—*Chilling of wet and dry seeds. Germination percent.*

			Laboratory	Chilled	Frozen
acuminata	Wet	2 days ...	94	86	4
		7 days ...	92	57	0
	Dry	2 days ...	93	81	84
		7 days ...	74	79	63
Balbisiana	Wet	2 days ...	46	44	9
		7 days ...	34	19	0
	Dry	2 days ...	64	76	79
		7 days ...	38	36	39

All main effects and two first order interactions were highly significant. *M. acuminata* germinated better than *M. Balbisiana ;* dry seeds were better than wet ; cold was bad for the seeds, freezing much worse than mere cooling ; two-day treatments were better than seven-day ones. The species-chilling interaction showed that seeds of *M. acuminata* were more affected by cold than those of *M. Balbisiana ;* and the chilling-wetness interaction that dry seeds were hardly affected by cold whereas wet seeds were severely affected.

The chilling-species-wetness interaction was also significant (at the 5 per cent. level) ; it qualifies the conclusion from the two foregoing interactions in the sense of showing that dry seeds of *M. acuminata* are not or are only a little more sensitive to freezing than those of *M. Balbisiana* but that its wet seeds are much more sensitive.

C. Storage problems—conditions for maintenance of viability.

Experiment X. M. Balbisiana. There were ten treatments (5 x 2), once replicated :—

Seeds stored in desiccator *versus* seeds stored in cloth bags in laboratory.

Seeds stored for 0, 3, 6, 12 and 24 months.

Results were :—

TABLE 11—*Storage in desiccator and in the laboratory. Germination percent.*

Months of Storage	Desiccator	Laboratory
0	73	89
3	95	93
6	95	88
12	95	5
24	93	0

Analysis of variance of angles gives highly significant variance ratios for all treatments :—

Item	D.F.	M.S.	V.R.
Times	4	1231	45.0***
Storage	1	4007	146.5***
T x S	4	1528	55.9***
Error	10	27	—

Desiccator is better than laboratory storage after about six months, when the undried seeds lose virtually all viability.

Experiment XI. M. Balbisiana. There were twelve treatments (2 x 6) once replicated :—

Seeds cleaned and sun-dried *versus* seeds dirty and wet.

Storage for 0, 1, 2, 4, 8 and 16 weeks in the laboratory.

Results were :—

TABLE 12—*Storage of clean and dirty seeds. Germination percent.*

	Weeks of Storage					
	0	1	2	4	8	16
Dirty and wet ...	68	0	0	0	0	0
Clean and dry ...	85	77	78	48	57	61

Storage of uncleaned seeds is evidently quickly lethal. Clean, dry seeds seem to suffer some decline in viability in the four months of this experiment but the regression of germination on time, though negative (1.3 per cent. per week), is not significant.

D. *Laboratory and greenhouse technique*

Experiment XII. M. Balbisiana. Seeds were sown in petri dishes in the laboratory in light and dark. Germinations occurred for a month and after six weeks the ungerminated seeds were transferred to pots in the greenhouse and records made there for another four months. Two experiments were carried out and the results, which were very similar, are summarized here as one experiment.

Results were:—

TABLE 13—*Germination in petri dishes and in the greenhouse. Actual numbers, percentages in brackets*

	Petri Dishes		Greenhouse	
	Light	Dark	Light	Dark
Germinated ...	38(13)	9(3)	45(18)	151(49)
Not germinated ...	255(87)	311(97)	210(82)	160(51)

$Chi^2_{[1]}=22.3***$ $Chi^2_{[1]}=59.1***$

In petri dishes, seeds germinated better in the light than in the dark but the ungerminated residue when transferred to the greenhouse gave better germination among those seeds which had previously been kept in the dark than those which had been kept in the light. Evidently, treatment in petri dishes does not realise all the potential viability of the seed. The effect of light and dark is the same as that found in Experiment VI.

Experiment XIII. M. Balbisiana. There were 12 treatments ($3\times2\times2$) each replicated once, and the whole experiment was replicated as a second series. Treatments were:—

Sand *versus* greenhouse soil.

Shallow ($2\frac{1}{2}$ inches) *versus* deep (4 inches) boxes.

Boxes undrained (with solid wooden bottoms) *versus* half-drained (holes cut in the corners protected with coconut fibre) *versus* well-drained (bottoms slatted and protected with dried cocoa leaves).

Primary replications were in half-boxes; the whole experiment was laid out in one block in the greenhouse, the two series kept separate but treatments randomized with respect to position within a series. The greenhouse soil was light in texture and was mixed from soil, compost and sand.

Results were:—

TABLE 14—*Greenhouse technique. Germination percent.*

	Sand		Greenhouse Soil	
	Shallow	Deep	Shallow	Deep
Undrained ...	32	61	61	62
Half-drained ...	31	42	57	61
Well-drained ...	62	65	61	54

The analysis of variance (angles) was:—

Item	D.F.	M.S.	V.R.
Soil	1	394	17.5***
Depth	1	242	10.7**
Drainage	2	266	11.8***
Series	1	59	—
Soil x Depth	1	185	8.2**
Soil x Drainage	2	257	11.4***
Depth x Drainage ...	2	100	4.4*
Other interactions ...	13	(All insignificant).	
Error	24	23	—

Conclusions are that greenhouse soil is better than sand, that deep are better than shallow boxes and that well-drained are better than undrained boxes which themselves, perhaps surprisingly, are better than half-drained ones. The interactions, however, qualify these conclusions, as follows:— with well-drained boxes, depth does not matter; deep boxes are only better where drainage is poor. Likewise, with greenhouse soil, depth is unimportant; it only matters with sand. Finally greenhouse soil is virtually unaffected by drainage but sand is quite sensitive to any degree of poor drainage.

Experiment XIV. M. Balbisiana. There were 48 ($2\times3\times2\times2\times2$) treatments without replication. Treatments were:—

Clay pots *versus* boxes.

Sand (a coarse, micaceous river sand) *versus* greenhouse soil *versus* ordinary soil.

Lime *versus* no lime.

Mixed artificials *versus* none.

Three waterings per day *versus* one watering.

Results were:—

TABLE 15—*Greenhouse technique. Germination percent.*

			Pots			Boxes		
			Sand	G. Soil	Soil	Sand	G. Soil	Soil
Lime	Artificials	3 wtgs.	88	78	66	58	46	6
		1 wtg.	90	76	96	36	38	26
	None	3 wtgs.	78	94	88	64	54	90
		1 wtg.	92	80	100	36	60	98
None	Artificials	3 wtgs.	60	78	6	52	74	36
		1 wtg.	86	84	24	70	76	34
	None	3 wtgs.	78	66	72	6	70	84
		1 wtg.	88	92	88	26	90	94

A condensed analysis of variance of angles is:—

Item	D.F.	M.S.	V.R.
Soils	2	153	3.8
Containers	1	1724	42.7***
Lime	1	38	—
Watering	1	274	6.8*
Artificials	1	1073	26.6***
SC	2	276	6.8*
SL	2	575	14.2**
SW	2	217	5.4*
SA	2	2280	56.4***
CL	1	514	12.7**
CW	1	7	—
CA	1	108	2.7
LW	1	424	10.5**
LA	1	0	—
WA	1	17	—
SCL	2	456	11.3**
SLW	2	335	8.3**
CLA	1	1024	25.3***
Other 2nd orders	11	(all non-significant)	
SCLA	2	170	4.2*
Other 3rd order + 4th order	9	40	—

Error has been made up of the third order interactions (less the SCLA item) plus the one fourth order interaction; it has 9 degrees of freedom and a rather high mean square. Conclusions are, with so many significant interactions, complicated; they may be briefly summarized as follows: (statements marked with an asterisk (*) are based on interpretation of the largest variance ratios and accordingly represent the most definite conclusions): *pots are better than boxes; *artificials reduce germination; one watering per day is better than three. Study of the interactions qualifies these conclusions as follows:—

*Artificials improve germination in sand, do not affect greenhouse soil and are bad in ordinary soil. *Ordinary soil is improved by lime but greenhouse soil is made worse. *Pots are improved by lime, boxes made worse. Unlimed treatments are better for only one watering but limed treatments are indifferent. Sand is better in pots than in boxes, greenhouse soil and ordinary soil are hardly affected by the container. *Ordinary soil is better with only one watering per day; sand and greenhouse soil show little difference. *Ordinary soil is improved by lime in pots but not in boxes; sand is indifferent to lime in pots or boxes and greenhouse soil is made worse by lime, more so in boxes than in pots. Artificials are worse for ordinary soil in boxes than in pots. Without lime any soil and with lime ordinary soil is better for a single watering; sand and greenhouse soil with lime are better for three waterings. *Boxes with lime and artificials are much worse than pots similarly treated; there is little difference between boxes and pots with other combinations of lime and artificials. Interpretation of the 3rd order SCLA is not attempted.

Obviously there is scope here for much further work but the practical conclusion seems to be that boxes of greenhouse soil lightly watered or pots of sand are the most satisfactory media for germination.

Experiment XV. M. acuminata. There were six treatments (3×2) once replicated.

Seeds planted at the surface and at half and one inch.

Sand *versus* greenhouse soil.

Results were:—

TABLE 16—*Depth of planting. Germination percent.*

	Surface	½ inch	1 inch
Sand	51	55	41
Greenhouse soil	55	63	66

Analysis of variance of angles is:—

Item	D.F.	M.S.	V.R.
Soil	1	156	15.3**
Depth	2	15	1.5
S x D	2	42	4.1
Error	6	10	—

Greenhouse soil, again, is better than sand (at least in boxes, as in this experiment); depth is quite insignificant and the soils agree as to the effect of depth.

4. Conclusions

Conclusions may conveniently be set out under the headings indicated above in the introduction.

1. *Experimental and breeding technique.* Seed should be extracted from mature and ripe fruits, ripeness being particularly important if the fruits are at all immature (Expt. I). Blackening or rotting should be avoided (Expts. II and III). Seeds from mature fruits may be sown at once or dried before sowing (Expts. I and II); those from immature fruits are probably better not dried (Expt. I). If storage is necessary the sun-dried seeds may be kept in the laboratory for up to six months without special treatment; for longer periods they must be stored in a desiccator and should then remain viable for at least two years (Expts. IV, X). Storage of wet seeds or of seeds from which the damp pulp has not been removed is to be avoided (Expts. VI and XI). Pre-sowing treatments (such as chipping of testas; scorching; soaking in sulphuric acid; subjection to temperature shocks; soaking in water for periods of two days to sixteen weeks) are either without effect or are deleterious; they never improve germination (Expts. IV-IX). In the greenhouse the most important thing seems to be freedom from excess water; hence light soil, well-drained boxes and light watering are indicated (Expts. XIII, XIV). Depth of planting (from 0 to 1 inch) does not matter (Expt. XV). Lime and artificial manures are probably better avoided (Expt. XIV). This greenhouse technique realises most or all of the germination of which the seed is capable and, in addition, maintains the seedlings in good condition until they can be potted out. If tests of viability alone are required pots of river sand are quite satisfactory (Expt. XIV) and have the advantage that they permit the reproduction of rather uniform conditions for experiment. They could be used for raising seedlings but would necessitate early pricking-out. The use of petri dishes and filter paper is not satisfactory for germination tests since it does not realise all the germination of which the seed is capable (Expt. XII).

An example of the importance and value of correct greenhouse technique may conveniently be described here. In the breeding of tetraploid bananas from the triploid Gros Michel (female) crossed by a diploid male parent, the average seed yield varies from less than one to about four seeds per bunch of Gros Michel. These seeds, when sown, may be inviable; or they may give rise to dwarf heptaploids or aneuploids, all virtually useless to the breeder; or they may give rise to the tetraploids which it is the object of the cross to produce. Obviously, since the production of the seed is a comparatively difficult and expensive operation, a greenhouse technique which realises the maximal possible yield of tetraploid seedlings is of the utmost importance. Table 17 shows how the substitution of a greenhouse soil for ordinary soil doubled the yield of the desirable tetraploids. And, since the production of seed was limiting to the progress of the breeding scheme at the time, it doubled also the output of potentially valuable seedlings.

TABLE 17—*Germination of seeds of the Gros Michel banana. Data from the records of the Banana Breeding Station, Bodles, Jamaica*

Soil	Seeds sown	Percent.		
		Inviable	Dwarfs, &c.	Tetraploids
Ordinary ...	1748	92.2	3.5	4.3
Greenhouse ...	2843	79.3	12.1	8.5

2. *Technique of collection of bananas.* The aim when collecting bananas in the wild state is not so much to obtain maximal germination as to achieve at least a minimal germination, sufficient merely to establish (in most cases) five to ten plants of the new form. It becomes important to know therefore what departures from standard technique are possible in response to the varied exigencies of conditions in the field, far from laboratory and greenhouse. The experiments described here show that: seed (so long as it is hard and black) may be extracted from immature fruit with fair hope of success but that if this is done it is best to ripen the fruit before extracting the seed (Expt. I); some overripeness or even rotting of the fruit before the extraction is deleterious to the seed but not lethal. (Expts. II and III); seeds, once extracted must be well cleaned (Expt. XI) but may then remain moist for a few weeks (Expt. VI) and may, by sun-drying, be preserved for six months or more (Expts. IV and X); dry seeds may safely be exposed to low temperatures for periods up to a week at least so that transport in aircraft flying at altitude or in surface mails in cold weather should do no harm. (Expts. VIII and IX).

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THE INTERCEPTION OF RAIN WATER BY A VEGETABLE MULCH

By G. ap GRIFFITH

It is commonly accepted that one of the effects of a vegetable mulch is to raise the moisture content of the underlying soil. This effect is at present being investigated at the College and results up to date appear to show that it is not always true under Trinidad conditions that soil under a mulch is wetter than bare soil.

It is to be expected that the major effects of a mulch will be to reduce evaporation and run off from the soil surface and thus to increase soil moisture. The purpose of this note is to draw attention to another effect which operates in the opposite direction, namely, interception of rain water and its re-evaporation before it enters the soil.

In order to obtain an approximate measure of this effect, a six-inch layer of Elephant Grass (*Pennisetum purpureum*) cut into suitable lengths was placed in two rain gauges and left in the open, side by side, with two empty rain gauges nearby. Daily records of the rain water collected from the two sets were kept from January 9th to July 26th, 1951.

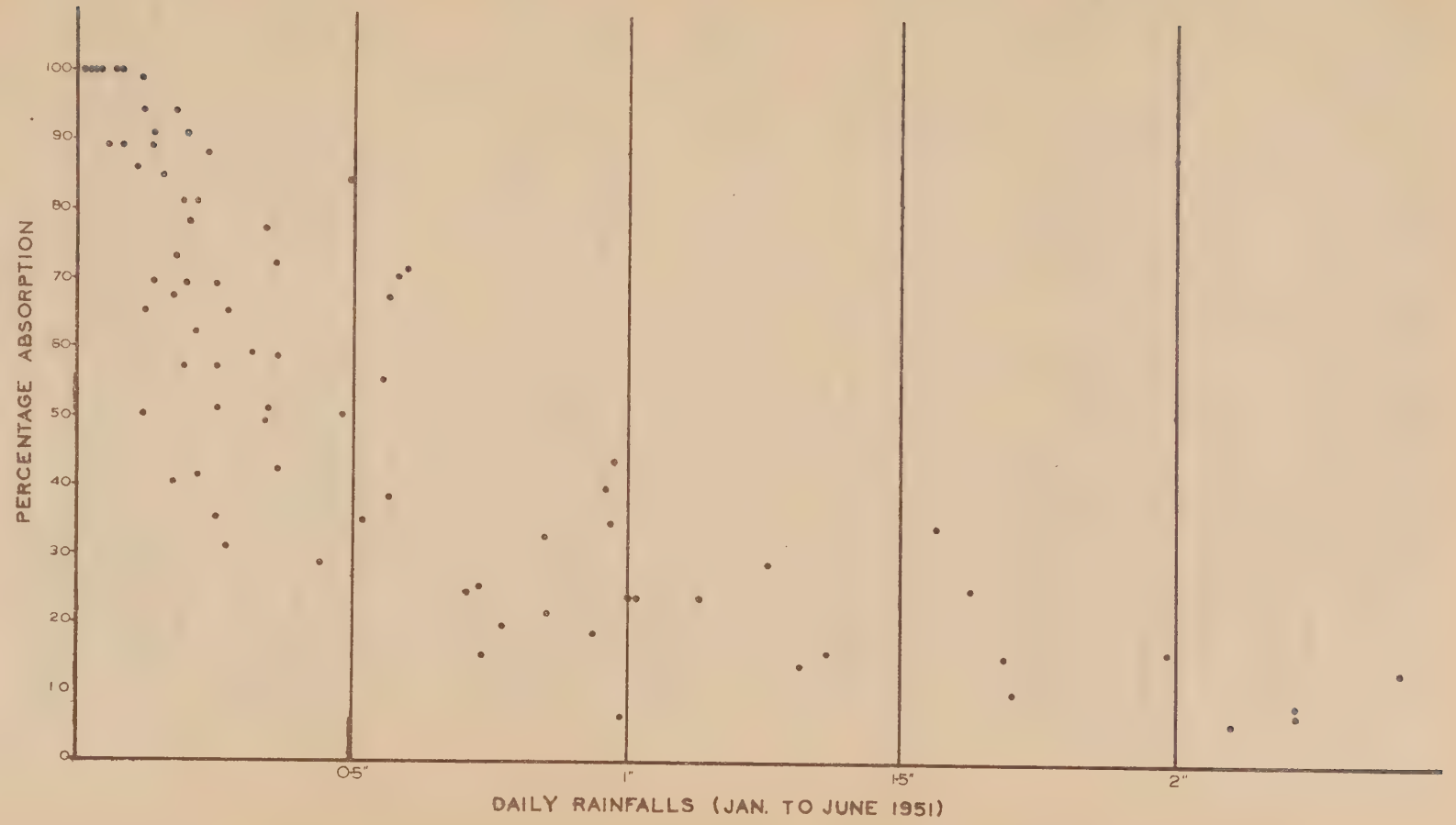
Over this period, the total rainfall measured was 54.9″. The amount which penetrated the mulch was 39.9″. Rain amounting to 15.0″, or 27 per cent. of the total precipitation, thus failed to penetrate the mulch.

The percentage retained varied, as would be expected, with the intensity of the rainfall. This variation is shown both in the following table (Table I) and in the accompanying diagram.

TABLE I—*Percentage of monthly rainfall intercepted by a six-inch layer of Elephant Grass*

Month (1951)	Rainfall (inches)	Percentage of rainfall intercepted
January	5.3	37
February	10.7	22
March	2.7	70
April	3.2	50
May	8.8	32
June	13.9	17
July	10.3	18
Total for 7 months	54.9	27

ABSORPTION OF RAIN BY ELEPHANT GRASS MULCH



The diagram shows (i) that a daily rainfall of less than 0.1″ will not penetrate a mulch of this thickness, (ii) that of a daily rainfall of less than 0.25″, over 75 per cent. will probably be retained, and (iii) that even when the rainfall is up to 0.6″ in a day, over 50 per cent. of the rain will fail to reach the underlying soil.

It is possible therefore that, under some circumstances, a mulch will have the effect of drying the soil underneath and that this is perhaps most likely to happen during periods, or in localities, having lower and less intense rainfall. Records kept for over two years at La Reconnaisance Estate, Lopinot Valley, Trinidad, showed that the soil under a bagasse mulch was almost consistently drier, presumably because of the lower intensity of rainfall, during two years of observations.

Records at St. Augustine, on the other hand, indicate that a mulch may dry the soil in the wet season and wet it in the dry season, indicating that, in the dry season, protection of the soil against evaporation is the more important effect, whereas, in the wet season, interception of rain is important. These results require confirmation.

It remains also to determine how the evaporation from a bare soil compares with that from a vegetable mulch. Information on this point may shortly be forthcoming from the soil evapotranspirometers now installed at the College Meteorological Station.

The measurements described above were carried out concurrently with sawdust and sugar cane bagasse with essentially similar results. Under field conditions, of course, the effect of these comparatively slow rotting materials on retention of rain will persist longer than in the case of Elephant Grass which persists for about six months.

Retention by different thicknesses of mulch

The results reported above were obtained using a 6″ Elephant Grass mulch. Essentially similar results were obtained with a 3″ mulch of sugar cane bagasse (25 per cent. retention over the period of measurement). Bagasse was therefore used in a second series of measurements made to determine the effect of different thicknesses of mulch upon the interception of rain.

Rain gauges containing as nearly as possible 1″, 3″, 5″, and 7″ thicknesses of bagasse were set up : the weight of bagasse in each case was also recorded. In each case the top of the mulch was brought level with the top of the gauge by supporting it on a gauze frame. Measurements were begun on August 22nd. and continued to the end of the year. The results are summarised in the following table.

TABLE II—*Percentage of rainfall intercepted by different thicknesses of Bagasse Mulch*

Period	Rainfall (inches)	Thickness of mulch * 1″	3″	5″	7″
August 22–September 30	12.3	31	37	39	45
October	3.9	63	74	72	75
November	6.9	36	41	37	40
December	3.3	56	57	54	53
Total for period	26.0	40	46	45	49

There is little difference between the percentage retention in the range of thicknesses examined. The implications are that most of the evaporation from the mulch takes place from the top inch and that within the ordinary limits of dressings used little difference need be expected in the amount of rain intercepted. Obviously if sufficiently massive dressings of mulch are used they may be sufficient to retain the rain by mere absorption.

*The weights of bagasse used were for the 1, 3, 5 and 7 inch dressings respectively 103, 244, 350, and 495 gms.

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SOME ASPECTS OF WEED CONTROL IN TRINIDAD

BY

F. H. B. BLACKBURN (1), D. M. HANSCHELL (2) AND M. CLARKE (1)

(*Paper read at the* 1951 *Conference of the B.W.I. Sugar Technologists Association, held in British Guiana*).

Summary

The results of a survey of Trinidad sugar cane fields have shown that the most abundant and often dominant weed species are annual grasses and herbs while the creeping perennial grasses, which were formerly important and difficult to control, have been largely eliminated by deep mechanical cultivation in the dry season. The standard method of weeding, with cutlass or hoe, is inefficient and moreover makes heavy demands on a labour force already fully engaged in other essential operations. Under these conditions pre-emergence weed control with the sodium salt of 2,4-D has proved highly successful.

Introduction

One of the most significant advances of recent years in Trinidad sugar cane agriculture has been the development of a system of mechanical cultivation in which all preparatory tillage operations take place in the dry season (1). Planting now begins shortly after the onset of the rains and can be completed within a few weeks. These conditions have given rise to much higher yields of plant cane than hitherto seemed feasible ; they have also posed a problem in weed control. In past years furrows were made across the bed by hand in the wet season and planting operations extended from July to November. During this period it was necessary to keep clean only those fields already planted at any given time ; elsewhere weeds were allowed to grow until the land was required for planting. Under the new system heavy weed growth throughout the plant cane acreage must be controlled at a time when labour should be fully occupied in other tasks : cleaning and digging drains, cutting plants, planting, weeding ratoons, applying fertiliser and insecticides. Moreover in certain areas labour is further depleted to plant rice and food gardens.

To meet this situation chemical weed control has been developed on a large scale at Caroni during the past three years. Interest in the use of herbicides is increasing, both in Trinidad and elsewhere in the B.W.I., and has prompted the presentation of this paper in which a description is given of the weeds of Trinidad cane fields and an approach to their control.

The Distribution of Weed Species

A survey of the distribution of weed species was carried out during 1950–51 and an estimate made of their relative abundance and importance. The fifty fields examined were representative of the major soil types of the sugar belt and of all stages of the crop cycle. Full details of the survey are available in Appendix I—the main findings are presented below :

1. Research Dept.—Caroni Ltd., T'dad. 2. Depart. of Agric., T'dad. and Tobago.

SPECIES GENERALLY ABUNDANT AND OFTEN DOMINANT

Weed Species	*Common Name (T) in Trinidad (B) in Barbados*	*Response to 2, 4–D*
COMPOSITAE		
Eleutheranthera ruderalis ...	... —	V.S.
COMMELINACEAE		
Commelina diffusa) ...	...Pond grass (B)	V.S.
„ elegans) ...	...Water grass (T)	
CYPERACEAE		
Cyperus rotundus ...	...Nut grass	S
EUPHORBIACEAE		
Euphorbia hirta ...	...Milkweed	S
„ hypericifolia	... —	S
„ thymifolia	...Poverty weed (B)	S
GRAMINEAE		
Digitaria sanguinalis)		R
„ horizontalis)	...Crab grass	R
„ violascens)		R
Eleusine indica ...	...Fowlfoot grass (T, B)	R
Panicum fasciculatum ...	...Birdseed grass (T)	R
*Paspalum fasciculatum ...	...Bamboo grass (T)	R
Rottboellia exaltata ...	...Corn grass (T)	R**

SPECIES OCCURRING FREQUENTLY AND ALTHOUGH SELDOM CONTRIBUTING MUCH TO THE "WEED BULK" ARE SOMETIMES ABUNDANT

Weed Species	*Common Name (T) in Trinidad (B) in Barbados*	*Response to 2, 4–D*
BORAGINACEAE		
Heliotropium indicum ...	... Eyebright (T) / White clary (B)	S
COMPOSITAE		
Ageratum conyzoides ...	...Herbe a femme (T)	S
Emilia sonchifolia ...	... —	S
Erechthites hieracifolia ...	... —	S
Eclipta alba ...	...Congo lala (T)	S
CYPERACEAE		
± Fimbrystylis miliacea ...	... —	S
± Torulinium ferax ...	... —	S

*Bamboo grass, in general locally abundant only where it has encroached from the field traces or drain edges.

**Resistant but shows symptoms of injury.

± These species are only locally abundant near the drain edges and in low lying, poorly drained areas.

Weed Species	*Common Name (T) in Trinidad (B) in Barbados*	*Response to 2, 4–D*
CUCURBITACEAE		
Momordica charantia ...	... Carilla (T), Carilee (T), Cerassee (B)	S
EUPHORBIACEAE		
Caperonia palustris ...	... —	S
Croton lobatus ...	... —	S
Phyllanthus graminicola)		
„ niurii)	Seed-under-leaf (B)	S
„ urinaria)		
GRAMINEAE		
Echinochloa colonum ...	...Jungle rice	R
Leptochloa virgata ...	...Feather grass	R
LOGANIACEAE		
Spigelia anthelmia ...	... Wormbush (T), Loggerhead (B)	V.S.
RUBIACEAE		
Borreria latifolia ...	... —	S
„ ocymoides ...	... —	S
Spermacoce tenuior ...	... —	S
SCROPHULARIACEAE		
Pagesia dianthera ...	... —	S

The status of the perennial grasses

With the exception of *Paspalum fasciculatum* (bamboo grass), *Cyperus rotundus* (nut grass), *Torulinium ferax*, *Leptochloa virgata* (feather grass) and *Commelina* spp. all the species in the above list are annuals and spread by seed.

The creeping perennials *Panicum purpurascens* (Para grass) and bamboo grass were formerly abundant and expensive to control ; they are no longer important weeds. Bamboo grass is still the main growth on most traces and care must be taken to prevent its encroachment into the cane fields. Indeed bamboo grass occurs in this list only by virtue of its occasional local abundance at the edges of fields and in drains and ravines. Nevertheless the past status of the perennial grasses is evident from the division of estate

weeding expenditure into "ordinary weeding" and "digging and heading of Para (and bamboo) grass". Their decline in importance can be traced to the much less widespread use of pen manure, which contains these grasses in various stages of decomposition, often still viable, and to the introduction of dry season mechanical cultivation ; for the intense desiccation which accompanies such thorough cultivation prevents their persistence in vegetative form. Reinfestation can occur only by encroachment from outside and, less important, by the germination of seeds. Where the full sequence of share ploughing, short interval of dry weather and chisel cultivation has not been carried out, as for example in the conversion of coconut fields to cane, the perennial grasses still occur in their former abundance.

The influence of soil conditions

The results of the survey indicate that, in general, soil type has had little influence on the weed flora ; that climate and cultural practices, near-uniform throughout the area, have been dominant in determining the pattern of distribution. Thus the weeds in the preceding list form the bulk of the growth in all fields. Similarly *Fimbrystylis miliacea*, *Peperomia pellucida*, *Torulinium ferax*, *Jussiaea* spp., *Sphenoclea zeylanica* and, in less degree, *Pagesia dianthera* and *Commelina elegans* occur in most drains and badly drained places. Less markedly *Sesbania sericea*, *Blechum brownei* and *Bidens pilosa* (railway daisy), frequently conspicuous on the edges of the fields, can rarely be found inside.

There are, however, certain exceptions to this general rule of uniformity. *Rottboellia exaltata* (corn grass), a troublesome weed, occurs in abundance only on light soils ; it was not recorded for example on the Frederick heavy clays where *Echinochloa colonum* (jungle rice) is the only grass of importance. Feather grass and *Digitaria* spp. (crab grass) also occur frequently on Frederick clays but are of little consequence ; *Eleusine indica* (fowlfoot grass) and *Panicum fasciculatum* (birdseed grass), of major importance elsewhere, are usually absent. Similarly *Panicum zizanoides* (bamboo seed grass) was found only in one localised area, the north-east of the northern plain.

The Weed Problem

Such, then, are the weeds. As stated briefly in the introduction their control throughout the plant cane acreage by the traditional methods of hand labour has been inadequate ; even the measure of success achieved has often been at the expense of ratoons which, by and large, have been neglected. And with some reason for, unlike plants, ratoons in past years have been subject to severe and unpredictable froghopper damage ; there could be no certainty that money spent on them would be recovered at harvest.

This somewhat depressing situation exists no longer ; it was reported to the 1949 meeting of this conference that the froghopper could be controlled in its nymphal stage by the correct use of either benzene hexachloride or chlordane (2). Although highly successful and now standard estate practice

throughout Trinidad the method demands that the insecticide be applied to the soil in and around the cane stools, which therefore must first be cleaned. But froghopper nymphs appear shortly after the onset of the rains when the available labour is fully occupied in planting and later in preventing the young plants from being smothered by weeds ; none can be spared to clean ratoons. Both chlordane and benzene hexachloride have considerable residual value ; the urgency of these labour demands can therefore be removed to some extent in areas of normal heavy infestation by dusting clean ratoons even before the appearance of nymphs—and weeds.

The suppression of weeds is desirable for reasons other than the promotion of froghopper control. It has been shown elsewhere that inadequate weed control during the first six weeks of cane growth, even with full control thereafter, can cause 45 per cent. reduction in yield (3). Such conditions exist in many parts of Trinidad where the froghopper hazard has been responsible and perhaps also an excuse for the low level of sugar-cane agriculture. Makeshift devices adopted to eke out the inadequate labour supply of 1942-44, and not yet discarded, have caused further drastic reductions in standards. No accurate estimate can be given of the losses caused by such excessive weed growth. On one estate in 1950, however, few of the old ratoon fields were weeded (and dusted) before mid July. Their yields are compared with those of all other old ratoon fields of that estate in Table 1.

TABLE 1.

The effect of early weeding (and dusting) on the yield of old ratoons.

Field No.	Date weeded (and dusted)	Yield (Tons per acre)
1 P. R.	24.6.50	23.52
2 P. R.	24.6.50	28.75
C. P.	1.7.50	30.26
1 S. P.	4.7.50	30.74
2 D.	17.6.50	28.88
Weighted Mean		28.29
L. P.	Not	15.36
Z. P.		22.00
1 S.		21.11
2 S.	before	22.32
3 Sav.		22.79
1 D.		20.64
W. J.	August	20.49
2 S. U.		19.51
4 U.		22.11
16 U.		22.63
19 U.	1950	18.43
23 U.		13.15
25 U.		12.06
26 U.		15.58
27 U.		15.93
28 U.		18.65
31 U.		14.03
34 U.		21.13
Weighted Mean		18.57

The limitations of these data are fully realised ; no pretence is made for example that 9.72 tons per acre is an exact measure of the gain in ratoon yield due to early weed and froghopper control. Nevertheless it is surely beyond coincidence that 23.52 t.p.a., the lowest yield of the early cleaned fields is higher than the highest of the late cleaned fields, 22.79 t.p.a.

On another estate chemical weed control has allowed a spectacular increase in the average yield of plant cane from a record of 39.17 t.p.a. in 1949 to 53.84 t.p.a. in 1951 (Appendix II).

Thus the need of some labour saving method of weed control is beyond question.

Methods of Weed Control

Hand weeding

Formerly both plants and ratoons were worked by hoe ; the cutlass was used chiefly to brush down weed growth immediately before planting. As indicated earlier, marked changes have taken place since 1942-44. The hoe is now used infrequently and then only in young plant cane ; indeed its use to cut weeds often taller than the ratoons themselves would be well-nigh impossible.

Cutlass weeding is standard estate practice ; it is quicker and, if not very high standards are acceptable, it is also cheaper than hoe weeding, but careless strokes can leave frequent gaps in the cane rows. If clean cultivation is demanded, even the advantage of cheapness is lost. For the effects of cutlassing are temporary ; repetition at very short intervals is necessary and insufficient labour is available. Again we return to the basic fact that hand weeding, whether by hoe or cutlass, has proved inadequate in Trinidad.

Mechanical weed control

It would be most difficult to control weeds in the cane row itself by mechanical means without causing undue damage to the crop. Fortunately the need does not arise. Whole canes rather than 3-eyed setts are used as planting material ; they give rise to a thick line of vigorous young shoots which crowd out weeds within the row. Weeds between the rows become the main problem and can readily be controlled by machine. Inter-row cultivation with rotary hoes has, in fact, been used with success for such purposes on one estate for a number of years.

In this paper no thought is given to inter-row cultivation as a tillage operation ; its merits in weed control alone are under consideration. Weeding by rotary hoe is far more efficient than hand weeding but requires a definite field layout with an increase in row spacing from 5 to 6 feet. Rotary hoes are particularly suitable for weeding ratoon cane ; unfortunately they cannot be used in newly prepared land until planting has taken place or banks have been broken, by which time the weeds are fully established. They cannot be used in wet weather.

Chemical weed control

Chemical control has long been practised in various crops ; numerous substances have been tried and many techniques developed. Petroleum oils,

sulphuric acid, chlorates, borax, copper sulphate and compounds of arsenic were among the first used. They are generally phytotoxic and, except where marked morphological differences exist between weed and crop, their action is non-selective. Relatively large quantities are required and the materials are difficult and often dangerous to handle. None has been used in the Trinidad sugar industry.

Studies on the effect of growth substances, begun at Jealotts Hill in 1936, led to the discovery by Slade, Templeman and Sexton that MCPA* (Methoxone) and DCPA** (2,4-D) were effective herbicides which could be absorbed through the roots and leaves.

It was found that at very low rates of application these chemicals were highly effective against the majority of broad leâf species while grasses in the main were unaffected. They were also found to inhibit seed germination for some weeks after application (4).

For several years Methoxone and 2,4-D were used only as selective contact herbicides to control broad leaf weeds in cereal crops. In Trinidad, as in many other sugar growing areas where the main weeds have long been thought to be grasses, they appeared to be unsuitable.

Later their ability when applied to the soil to inhibit seed germination in both grasses and non-grasses led to the development in Hawaii in 1947 (5) of a new technique : pre-emergence weed control with 2,4-D. The term " pre-emergence " is used with reference to the emergence of the weeds and not the crop (cane). For cane is gramineous and is propagated by stem cuttings ; within certain limits it is non-susceptible to 2,4-D at any stage of the crop cycle.

There are many gaps in our knowledge of the reaction of 2,4-D with the soil, its persistence and ultimate fate, but soil type, climate and agricultural practices are known to be of importance. It is accepted that 2,4-D is absorbed to some extent by the soil ; its removal by leaching is slow and seldom complete and its disappearance is the result of decomposition by micro-organisms. The rate of disappearance seems to be influenced by soil reaction, organic matter content and lime status (6), (7).

Experience on a wide range of soil types is that cane germination and growth are apparently unaffected by applications not greater than 5 lbs. 2,4-D per acre. However, under certain conditions root injury and reduced germination from similar applications can be sustained and have been recorded in Hawaii (8).

Chemical Weed Control in Trinidad

Pre-emergence

Pre-emergence weed control with 2,4-D was clearly worthy of trial under Trinidad conditions. Preliminary tests carried out in 1948 and successfully

* 2–methyl, 4–chlorophenoxyacetic acid

** 2, 4–dichlorophenoxyacetic acid.

repeated on an extensive field scale led to the adoption of the following technique.

The weed free condition of the soil essential to pre-emergence control is achieved by cultivation operations and maintained when and where necessary by the repeated application of 2,4-D at intervals of 6-8 weeks. 20 gallons per acre of an aqueous solution containing 3 lb. commercial (80 per cent.) sodium salt of 2,4-D are applied by knapsack sprayers fitted with low volume (2TOC02) Boomjet nozzles adjusted to give spray patterns 5 feet in width, the standard cane row spacing. All fields are sprayed immediately after planting; an extra pre-planting application is given to early prepared (banked) fields in order to prevent weed growth resulting from crop time showers. Another application must be given roughly 6-8 weeks after planting when banks are broken and a fresh soil surface exposed. Further treatment may or may not be necessary depending on weather conditions and the " covering in " of the cane.

The efficiency of pre-emergence weed control is influenced to some extent by the surface condition of the soil ; it is lowest on uneven, cloddy land and very high on the silty clays of Trinidad.

Pre-emergence control is therefore particularly effective in ratoon fields where burning has removed the covering of trash to reveal an even, though consolidated, soil surface ; indeed this technique has been extended to ratoon cultivation with marked success.

Certain aspects of pre-emergence control merit further consideration. Under high rainfall conditions the bare surfaces of cambered beds are subject to considerable erosion ; the drain edges crumble and the drains are filled. It might be advisable, therefore, to allow low weed growth along the drain edges.

If planting is delayed and weeds germinate the clean surface essential to this technique can be re-established by breaking full banks immediately after planting. Moreover there are distinct advantages to be derived from the early restoration of the cambered bed surface : water is prevented from standing in the planted furrows and a much smaller soil surface must be protected from weed growth. However, to allow full banks to be broken at the time of planting, shallower furrows should be made.

The breaking of full banks immediately after planting has been carried out on a field scale with most successful results. Tiller counts have shown that, in comparison with standard planting methods, the breaking of full banks does not adversely affect germination (Table 2).

TABLE 2

The effect on tiller formation of breaking full banks at the time of planting

Date	Number of Tillers per Plot	
	Ordinary planting (Means of 6 plot totals)	Full banks broken at planting (Means of 6 plot totals)
	B.C.23 (B.4362)	
	Planted week ending 7th July, 1951	
28/7/51 ...	62.0 ± 4.8	60.0 ± 4.6
7/8/51 ...	94.8 ± 8.0	92.3 ± 4.3
14/8/51 ...	114.3 ± 11.3 Full banks broken	109.7 ± 4.7
17/8/51 ...	101.5 ± 11.1	120.9 ± 5.8
	Wilderness M.P. 15 (B.37172)	
	Planted week ending 30th June, 1951	
1/8/51 ...	169.0 ± 8.7	130.5 ± 4.2
7/8/51 ...	213.7 ± 14.3	168.2 ± 4.7
15/8/51 ...	316.7 ± 23.6	256.2 ± 14.6
22/8/51 ...	436.7 ± 25.1 Full banks broken	348.7 ± 9.2
27/8/51 ...	421.7 ± 7.4	406.2 ± 13.2
3/9/51 ...	520.3 ± 15.5	475.0 ± 14.4
31/9/51 ...	820.8 ± 9.3	920.0 ± 48.2

One further aspect is worthy of mention : only the sodium salt of 2,4-D has been used on a large scale in Trinidad. Preliminary trials indicate that, while ester formulations appear to hold little advantage over the sodium salt, amines of 2,4-D might be equally effective at lower rates of application and therefore cheaper.

Contact

In some Trinidad cane fields the dominant weed growth consists of species susceptible to the contact action of 2,4-D. To control such growth it has been found advantageous to increase the volume of solution used : 3 lb. commercial sodium salt of 2,4-D per acre are applied in 40 instead of 20 gallons of water. The responses of individual species to this treatment have been given in Appendix 1.

Acknowledgment

Grateful acknowledgment is made to Professor Baker and the staff of the Botany Department, Imperial College of Tropical Agriculture, for the identification of the species collected in the course of the weed survey.

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(*Received for publication, March,* 1952)

Appendix I—Weeds Occurring in Trinidad Sugar Cane Fields

V.S. = very susceptible ; S = susceptible ; P.S. = particularly susceptible ; R = resistant.

I. Species Generally Abundant and often Dominant

Weed Species	Common Name (T) Trinidad (B) Barbados	Growth Form	Response to 2, 4-D Contact spray
Compositae			
Eleutheranthera ruderalis (Sw) Sch. Bip.	—	Annual herb ...	V.S.
Commelinaceae			
Commelina diffusa Burm f. sens Merrill	Water grass (T)	Creeping perennial herb	V.S.
Commelina elegans H.B.K.	Pond grass (B)		
Cyperaceae			
Cyperus rotundus L. ...	Nut grass ...	Sedge	S
Euphorbiaceae			
Euphorbia hirta L.	Milkweed ...	Annual herb ...	S
Do. hypericifolia L. ...	... ...	do. ...	S
Do. thymifolia L. ...	Poverty weed (B) ...	do. ...	S
Gramineae			
Digitaria sanguinalis (L.) Scop.		Creeping annual ...	R
Do. horizontalis Willd.	Crab grass ...	do. ...	R
Do. violascens Link		do. ...	R
Eleusine indica Gaerth. ...	Fowlfoot grass ...	Tufted annual ...	R
Panicum fasciculatum Swartz....	Birdseed grass (T)	do. ...	R
	Brown top millet ...		
*Paspalum fasciculatum Willd.	Bamboo grass (T)	Creeping perennial	R
	Swamp grass (T)		
Rottboellia exaltata L. ...	Corn grass (T) ...	Tufted branching annual	R †
	Kelly grass (T)		

*Bamboo grass, generally only locally abundant where it has encroached from the field traces or drain edges.

† Though resistant shows signs of injury.

II.—Species Occurring Frequently and although seldom Contributing much to the "Weed Bulk" are Sometimes Abundant

Weed Species	Common Name	Growth Form	Response to 2, 4-D
Boraginaceae			
Heliotropium indicum L.	Eyebright (T) White Clary (B)	Annual herb	S
Compositae			
Ageratum conyzoides L.	Herbe a femme (T)	Annual herb	S
Emilia sonchifolia (L.) DC.	—	do.	S
Erechthites hieracifolia (L.) Raf.	—	do.	S
Eclipta alba (L.) Hassk.	Congo lala (T)	do.	S
Cyperaceae			
*Fimbrystylis miliacea Vahl.	—	Sedge	S
*Torulinium ferax (L.C.Rich) Urb.	—	do.	S
Cucurbutaceae			
Momordica charantia L.	Carilla, Carailee (T) Cerassee (B)	Climber	S
Euphorbiaceae			
Caperonia palustris (L.) St. Hil.	—	Annual herb	S
Croton lobatus L.	—	do.	S
Phyllanthus graminicola Britton Do. niuri L. Do. urinaria L.	Seed-under-leaf	do.	S
Gramineae			
Echinochloa colonum (L.) Link.	Jungle rice	Tufted much branched annual	R
Leptochloa virgata (L.) Beauv.	Feather grass	Tufted perennial	R
Loganiaceae			
Spigelia anthelmia L.	Wormbush (T) Loggerhead (B)	Annual herb	V.S.
Rubiaceae			
Borreria latifolia (Aubl.) Schum.	—	Annual herb	S
Borreria ocymoides (Burm.) DC.	—	do.	S
Spermacoce tenuior L.		do.	S
Scrophulariaceae			
Pagesia dianthera (Sw.) Pennell	—	Annual herb	S

*These species are only locally abundant near the drain edges and in low lying, poorly drained areas.

III.—Species Occurring in the Majority of Fields but Seldom in Abundance

Weed Species	Common Name	Growth Form	Response to 2, 4-D
Apocynaceae			
Prestonia quinquangularis (Jacq.) Sprong.	—	Perennial climber ...	S
Compositae			
Bidens pilosa L. ...	Railway daisy (T) Spanish needle	Annual herb ...	V.S.
Emilia coccinea (Sims) Sweet. ...	Tassel flower ...	do. ...	S
Convolvulaceae			
Ipomoea tiliacea Choisy ...	—	Climber ...	S
Leguminoseae			
Mimosa pudica L.	Ti Marie (T), Sensitive plant, Shame bush (T)	Perennial herb ...	P.S.
Onagraceae			
*Jussiaea decurrens (Walt.) DC.	—	Annual herb ...	V.S.
* Do. suffructicosa L. ...	—	do. ...	V.S.
Oxalidaceae			
Oxalis barrelieri L.	—	Annual herb ...	S
Solanaceae			
Solanum stramonifolium Jacq. ...	Cocochat, Dog teeth	Shrub	S
Umbelliferae			
Eryngium foetidum L. ...	Fit weed ...	Biennial herb ...	V.S.

*These species occur mainly near the drain edge and in low lying, poorly drained areas.

Weed Species	Common Name	Growth Form	Response to 2,4-D
Acanthaceae			
Blechum brownei Juss.	—	Perennial herb	S
Ruellia tuberosa L.	Minnie root, Many roots	do.	S
Amarantaceae			
Alternanthera ficoidea (L.) Lam.	Rabbit meat	Annual herb	S
Amarantus tristis Willd.	Spinach, Bhaji (T)	do.	S
Iresine celosiae L.	—	do.	—
Amaryllidaceae			
Hypoxis decumbens L.	—	Perennial	V.S.
Araceae			
Caladium bicolor (Ait.) Vent.	Wild eddo	Perennial	P.S.
Xanthosoma helliborifolium (Jacq.) Schott	Fowl-foot Bhaji	do.	S
Boraginaceae			
Heliotropium procumbens Mills	—	Annual herb	—
Campanulaceae			
*Sphenoclea zeylanica Gaertn.	—	Annual herb	P.S.
Cannaceae			
Canna edulis Ker-gawl.	Canna	Perennial herb	—
Capparidaceae			
Capparis ciliata Schum. and Thonn.	—	Annual herb	S
Capparis serrata Jacq.	—	do.	S
Commelinaceae			
Aneilema nudiflorum (L.) Wall.	—	Creeping perennial herb	V.S.
Compositae			
Chaptalia nutans (L.) Polak.	—	Perennial herb	S
Erigeron spathulatus Vahl.	—	Annual herb	—
Eupatorium odoratum L.	Christmas bush	Shrub	V.S.
Do. ivaefolium L.	—	do.	—
Porophyllum ellipticum (L) Cass.	—	Annual herb	S
Spilanthes ulginosa Sw.	—	do.	S
Do. ocymifolia (Lam.) A. H. Moore	—	do.	S
Synderella nodiflora (L.) Gaertn.	Porter bush (B)	do.	S
Tridax procumbens L.	—	Perennial herb	S
Veronia cinerea (L.) Less.	—		
Convolvulaceae			
Ipomoea quamoclit L.	—	Climber	S
Cyperaceae			
*Cyperus diffusus Vahl.	—	Sedge	—
* Do. luzulae Rottb.	—	do.	—
* Do. sphacelatus Rottb.	—	do.	S
*Dichromena radicans Schl. and Cham.	—	do.	
*Fimbrostylisdiphylla (Rotz.) Vahl.	—	do.	
*Kyllinga pumila Mich.	—	do.	
Scleria melaleuca Schl. and Cham.	—	do.	
Euphorbiaceae			
Acalypha arvensis Poepp. and Endl.	—	Perennial herb	S
Croton hirtus L'Her.	—	Annual herb	S

*These species occur mainly near the drain edges and in low lying, poorly drained areas.

IV.—Other Species Recorded—*Continued*

Weed Species	Common Name	Growth Form	Response to 2, 4-D
Dalechampia scandens L.	—	Climber	—
Euphorbia heterophylla L.	—	Annual herb	S
Sebastiana corniculata (Vahl.) Muell-Arg.	—	do.	S
Gramineae			
Andropogon bicornis L.	Broom grass (T)	Tufted perennial	R
Chloris radiata (L.) Swartz.	—	Tufted annual	—
Cynodon dactylon (L.) Pers.	Bermuda grass / Devils grass / Bahama grass	Creeping perennial	R
Eragrostis sp.	—	Tufted annual	R
Eriochloa punctata (L.) Desv.	Cup grass	Branching perennial	R
Panicum laxum Swartz.	—	Tufted annual	R
Do. purpurascens Raddi.	Paragrass	Creeping perennial	R
Do. zizanoides H.B.K.	Watergrass, Bamboo seed (T)	do.	R
Paspalum conjugatum Bergius	—	do.	R
Setaria geniculata (Lam.) Beauv.	Bristle grass	do.	R
Sporobulus indicus (L.) R. Br.	Tapia grass (T) / Wire grass	Tufted perennial	R
Labiatae			
Leonotis nepetaefolia (L.) R. Br.	Lion's tail (B)	Annual herb	S
Leonurus sibiricus L.	—	do.	
Hyptis capitata Jacq.	—	do.	
Marsypianthes chamaedrys (Vahl.) Kuntze	—	do.	
Leguminoseae			
Aeschynomene americana L.	—	Annual	—
Do. sensitiva Sw.	—	Shrub	R
Desmodium frutescens (Jacq.) Schindl.	Sweethearts, Cousin (T)	Annual herb	R
Flemingia strobilifera R. Br.	Wild hops	Shrub	—
Mimosa casta L.	—	do.	—
Phaseolus lathyroides L.	Wild dolly (B)	Annual herb	S
Rhynchosia minima (L.) DC.	Burnmouth (B)	Climber	—
Sesbania sericea (Willd) DC.	—	Shrub	V.S.
Teramnus labialis Spreng.	Rabbit vine (B)	Climber	S
Vigna vexillata (L.) A. Rich.	—	do.	—
Malvaceae			
Malachra sp.	Wild ochra	Subshrub	S
Sida rhombifolia L.	Broom (T)	do.	S
Passifloraceae			
Passiflora foetida L.	—	Slender climber	—
Piperaceae			
*Peperomia pellucida (L.) H.B.K.	Shine bush (T)	Annual succulent herb	S
Portulacaceae			
Portulaca oleracea L.	Purslane	Annual succulent herb	S
do. pilosa L.	Jump-up-and-kiss-me (T)	do. do.	S
Rubiaceae			
Borreria bartlingiana DC.	—	Annual herb	S
do. laevis (Lam.) Griseb.	—	do.	S
do. verticillata (L.) Mey.	—	Perennial herb	S
Oldenlandia herbacea (L.) DC.	—	Annual herb	—

* These species occur mainly near the drain edges and in low lying, poorly drained areas.

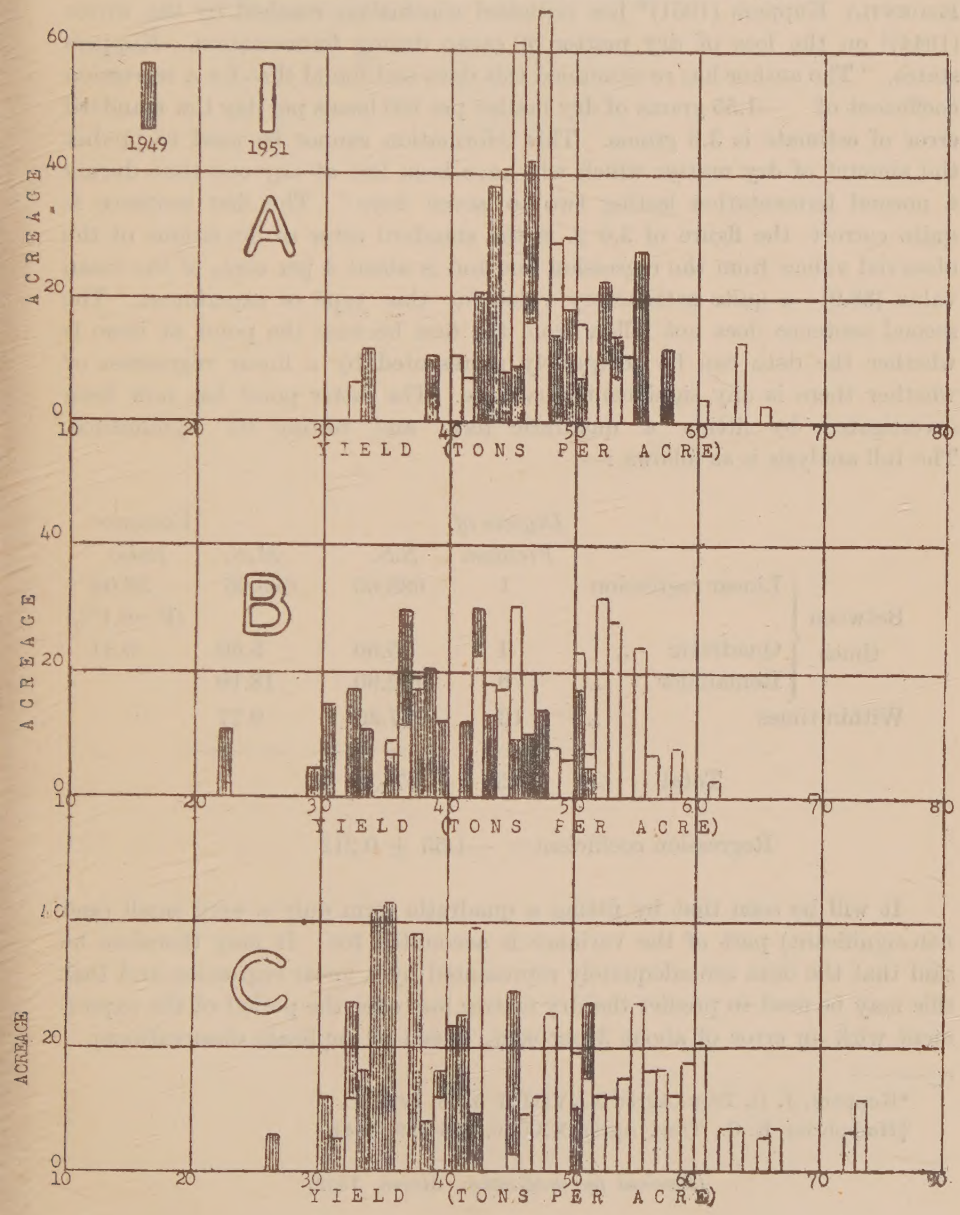
IV.—Other Species Recorded—*Continued*

Weed Species	Common Name	Growth Form	Response to 2,4-D
Sapindaceae			
Cardiospermum microcarpum H. B. K.	—	Slender climbers ...	S
Scrophulariaceae			
Scoparia dulcis L.	Sweet broome (T)	Herb	—
Solanaceae			
Browallia americana L. ...	—	Annual herb ...	—
Physalis pubescens L. ...	Pops (B) ...	do. ...	P.S.
Solanum nigrum var americanum (Mill) O. E. Schulz.	Agouma (T) ...	do. ...	—
Urticacaeae			
Fleurya aestuans Guad. ...	Nettle	— ...	S
Verbenaceae			
Lantana camara L.	Red flowered sage	Shrub	—
Do. involucrata L. ...	White sage ...	do.	—
Lippia betulaefolia (H.B.K.) Greene	—	Herb	—
Priva lappulacea (L.) Pers. ...	—	do.	S
Stachytarpheta jamaicensis (L.) Vahl.	Vervain	do.	S

APPENDIX 2

The effect of weed and frognopper control on the yield of plant cane on three sections of one estate

SECTION	YIELD OF PLANT CANE (Tons per acre) 1949 (record year)	1951	% CHEMICAL WEED CONTROL FOR 1951
A	46.70	48.49	nil
B	39.76	48.25	23.10
C	39.17	53.84	36.34



CHANGES IN THE ABSOLUTE DRY MATTER CONTENT OF CACAO DURING FERMENTATION

A Reply to Criticism

By

E. C. HUMPHRIES

Recently Kuppers (1951)* has criticised conclusions reached by the writer (1944)† on the loss of dry matter of cacao during fermentation. Kuppers states, " The author has re-examined this data and found that for a regression coefficient of —1.55 grams of dry matter per 100 beans per day the standard error of estimate is 3.6 grams. This information cannot be used to predict the amount of dry matter which will have been lost at any one time during a normal fermentation lasting two to seven days." The first sentence is quite correct, the figure of 3.6 g. is the standard error of deviations of the observed values from the regression line and is about 4 per cent. of the mean value (88.0)—a quite satisfactory value for this type of experiment. The second sentence does not follow from the first because the point at issue is whether the data can be adequately represented by a linear regression or whether there is any significant curvature. The latter point has now been investigated by fitting a quadratic term and testing its significance. The full analysis is as follows :—

		Degrees of Freedom	*S.S.*	*M.S.*	*Variance Ratio*
Between times	Linear regression	1	688.66	688.66	38.04 (P=0.1%)
	Quadratic ,,	1	5.60	5.60	0.31
	Remainder ...	9	162.90	18.10	
Within times ...		12	117.26	9.77	
Total ...		23	974.42		

Regression coefficient= —1.55 ± 0.212

It will be seen that by fitting a quadratic term only a very small (and non-significant) part of the variance is accounted for. It may therefore be said that the data are adequately represented by a linear regression and that this may be used to predict the dry matter loss over the period of the experiment with an error of about 3 per cent. (mean of duplicate observations).

*Kuppers, J. R. Trop. Agric. XXVIII. 1–6. 53. 1951.

†Humphries, E. C., Trop. Agric. XXI, 9. 166–169, 1944

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